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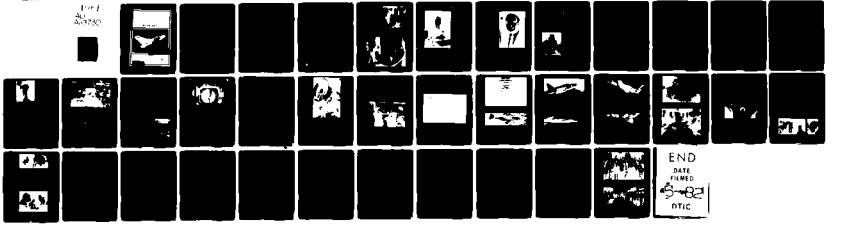

AGARD HIGHLIGHTS 82/1

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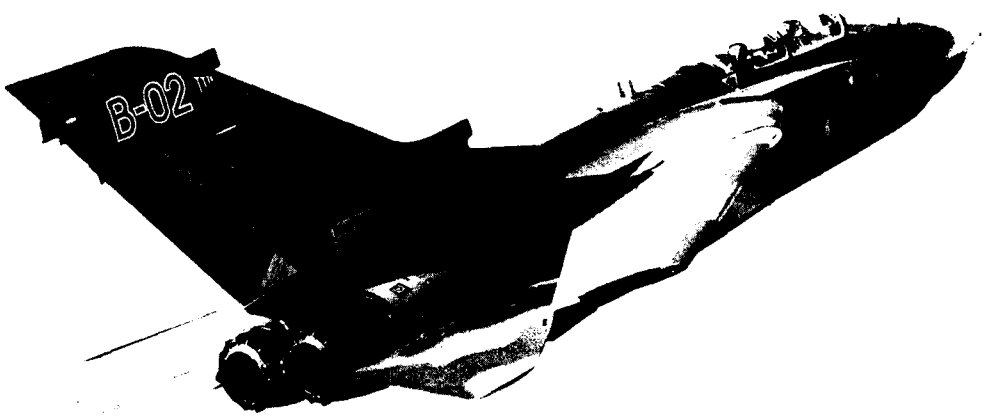
ADVISORY GROUP FOR AEROSPACE RESEARCH & DEVELOPMENT

HIGHLIGHTS



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AGARD HIGHLIGHTS 82/1
MARCH 1982

Front Cover:

PANAVIA TORNADO multirole combat aircraft are now in quantity production at British Aerospace, Warton, England (visited by the AGARD National Delegates Board in September last) and Messerschmitt-Boelkow-Blohm in the FRG. The third company involved, Aeritalia of Italy, is not scheduled to deliver its first aircraft until later this year. Altogether it is planned to build 809 aircraft, 165 of them being air defence versions for the Royal Air Force and the remainder the interdiction/strike version, ordered by Britain, the Federal Republic of Germany, and Italy. More than forty of the strike version have been delivered to the Tornado Tri-National Training Establishment at Cottesmore, U.K. As the TTTE marking on the leading edge of the fin indicates, our picture shows one of these Cottesmore aircraft.

THE MISSION OF AGARD

The mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

- Exchanging of scientific and technical information;
- Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;
- Improving the co-operation among member nations in aerospace research and development;
- Providing scientific and technical advice and assistance to the North Atlantic Military Committee in the field of aerospace research and development;
- Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field;
- Providing assistance to member nations for the purpose of increasing their scientific and technical potential;
- Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each member nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Programme and the Aerospace Applications Studies Programme. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

★ ★ ★

All members of AGARD, whether National Delegates, Panel Members or AGARD Staff, are cordially invited to submit articles likely to be of interest to other AGARD members for the next issue of AGARD HIGHLIGHTS which will appear in the Autumn of 1982. Articles should be addressed to:

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7, rue Ancelle
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Von Kármán Medal 1981

M. PHILIPPE POISSON-QUINTON, accompanied by his wife, receives his award from Dr Alan M.Lovelace, Chairman of AGARD

The presentation of the von Kármán Medal for 1981 took place during the 15th AGARD Annual Meeting in Oxford last September.

M. Poisson-Quinton, the Director of International Cooperation Programmes in the Office National d'Etudes et de Recherches Aérospatiales (ONERA), Châtillon, France, who was the recipient, is a well-known figure in AGARD circles and has, among his many activities, served as a member of the Flight Mechanics Panel since 1967. The text of the citation pertaining to this award was reproduced in our last issue, Highlights 81/2.

The new AGARD Chairman

PROFESSOR DR-IR. O.H.GERLACH

At its Meeting in Oxford in September last year, the AGARD National Delegates Board approved the proposal to appoint Professor Otto H.Gerlach of the Netherlands to the Chairmanship of AGARD for a period of two years. The appointment takes effect at the conclusion of the Spring 1982 NDB Meeting when the outgoing Chairman, Dr Alan M.Lovelace, will hand over the reins of office.

Otto H.Gerlach was born in Amsterdam on July 8, 1928. After finishing grammar school he attended the Delft University of Technology, receiving his master's degree in Science in Aeronautical Engineering in 1951 and a doctor's degree at the same university in 1964. During his study at the Delft University of Technology Professor Gerlach spent one year at the Dutch Government Flying School for flight training, leading to a professional pilot's license.

From 1954 until 1972 he was a member of the Advisory Committee of the NLR on flying qualities and aircraft operations. For many years he was a member of the Dutch Civil Aircraft Accident Investigation Board (equivalent to NTSB). In 1959 he was named associate professor and in 1965 became a full professor at the Department of Aerospace Engineering of the Delft University of Technology.

In 1971 he was appointed Chairman of the Board of the Foundation National Aerospace Laboratory.

Professor Gerlach is a Fellow of the Royal Aeronautical Society, Associate Fellow of the American Institute of Aeronautics and Astronautics, member of the "Deutsche Gesellschaft für Luft- und Raumfahrt (DGLR)", and International Member of the Daniel Guggenheim Board of Award.

....and Director

REAR ADMIRAL ROBERT K.GEIGER, USN (RET.)

At the end of June this year, when the present Director of AGARD, Mr Jack Burnham, relinquishes his appointment and returns to the UK, it has been recommended by the AGARD National Delegates Board that the post be filled by Mr Robert K Geiger of the US. The appointment will be for a period of three years.

Robert K.Geiger is a Systems and Research & Development Manager with some twenty-four years of experience in the fields of anti-submarine warfare, missiles, space systems, etc., and in general research and development management. He has had thirty-one years of military experience and is currently employed as an Assistant Vice President and Manager of the Falls Church, Virginia, branch of Science Applications Inc., involved with sensor systems operation.

His service as a naval officer commenced in 1947 and covered many appointments on board ship and as an aviator in the US Navy. He was appointed a Programme Manager on the P3C aircaft in 1963 and later held positions as Deputy Director (responsible for R&D, Advanced Planning and Studies) in the Office of the Secretary of the Air Force from 1966 to 1969 and subsequently in the Office of Space Systems under the Secretary of the Air Force. Among appointments which followed he was Chief of Naval Research in the US Navy from 1975 to 1978. Mr Geiger holds a Bachelor of Science degree in Naval Science from the US Naval Academy (1947), a B.S. in Ordnance Engineering from the US Naval Postgraduate School (1955) and a Master of Science in Aeronautical Engineering from the Massachusetts Institute of Technology (1956).

UK NATIONAL DAY

1981

UK National Day, Thursday 17 September 1981, was marked by an invitation from the United Kingdom National Delegates to all those attending the AGARD NDB Meeting in Wolfson College, Oxford, to visit the British Aerospace facility at Warton. The group was air-lifted for the visit from Royal Air Force Station, Brize Norton, under arrangements generously provided by the Company, and on arrival at Warton, after being received by Company officials, were formally welcomed by Mr D.J.Harper, Chief Scientist (RAF) and UK NDB member.

Mr Harper's presentation, which went on to outline current arrangements for the organisation and management of aerospace research in the UK, is reproduced below. Dr E.W.E.Rogers, a Deputy Director of the Royal Aircraft Establishment, Farnborough, and an NDB member also, then gave an overview (which follows) of the current scope of aerospace research in the UK.

* * *

Mr D.J.HARPER, United Kingdom National Delegate

INTRODUCTION

Dr Lovelace, National Delegates, Gentlemen. I am honoured to welcome you all to this UK National Day. The UK Delegates hope you will find what we have arranged both useful and interesting.

It is a long time since the Board last met in the UK, in 1968 in fact, and much has happened in the meantime in the organisation and management of aerospace research. We therefore thought you might find it useful if I were to give you first an outline of our current management arrangements. Dr Rogers will then give you an overview of the current scope of aerospace research in the UK. After that we come to the main part of the day's proceedings. British Aerospace is, of course, one of the largest contractors to the Ministry of Defence. It also carries out research and other technology work across a wide spectrum of our interests and we have therefore asked them to talk about and show you some of their work as typical examples of the kinds of aerospace research and technology work currently being done in the UK.

So much for the plan for the day. I will now describe the organisational arrangements within which aerospace research is now managed in the UK.

STRUCTURE OF MOD

Within MOD there are, in effect, five different departments, as shown in Figure 1. These are the three Service Departments – that is, the Navy, Army and Air Force Departments, the Procurement Executive, and the Central Staffs. In typical British fashion there are many interfaces between these and many senior appointments have responsibilities in more than one area. For example, I, as Chief Scientist (RAF), report to Vice-Chief of the Air Staff, in the Air Force Department. I am also a member of the Defence Scientific Staff and, hence, come under the Chief Scientific Adviser, of the Central Staffs. And, as Director General for Research for aerospace, I belong to the Procurement Executive. However, I will try to keep the following description simple!

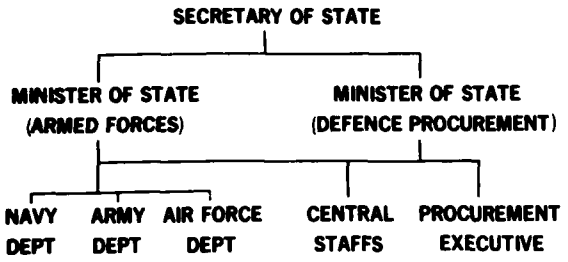
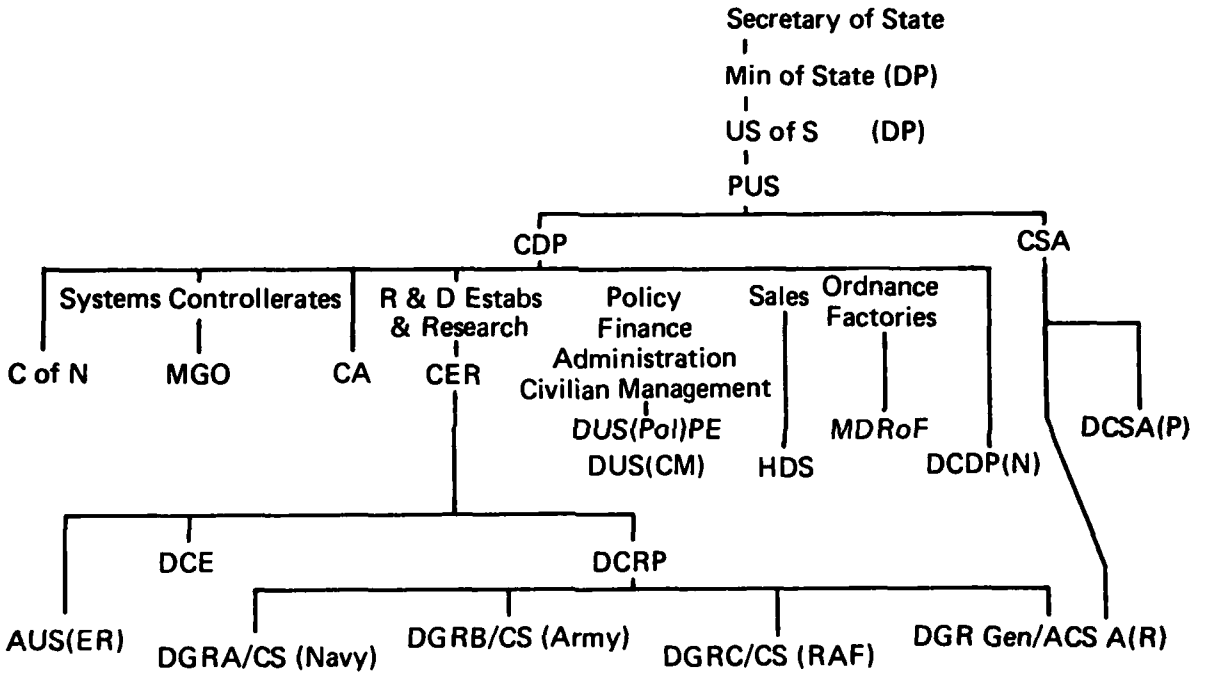


Fig.1 MOD UK Departmental Organisation September 1981

COMMITTEE	CHAIRMAN
DEFENCE RESEARCH AND INTRAMURAL RESOURCES	CHIEF SCIENTIFIC ADVISOR
OPERATIONAL REQUIREMENTS	DEPUTY CHIEF OF DEFENCE STAFF(OR)
DEFENCE EQUIPMENT POLICY	CHIEF SCIENTIFIC ADVISOR

Fig.2 Committees concerned with procurement



Min of State (DP)	Minister of State for Defence Procurement
US of S(DP)	Parliamentary Under Secretary of State for Defence Procurement
PUS	Permanent Under Secretary of State
CDP	Chief of Defence Procurement
CSA	Chief Scientific Adviser
C of N	Controller of the Navy
MGO	Master General of Ordnance
CA	Controller Aircraft
CER	Controller R & D Establishments & Research
DUS(Pol) PE	Deputy Under Secretary of State (Policy) Procurement Executive
DUS(CM)	Deputy Under Secretary of State (Civilian Management)
DCSA(P)	Deputy Chief Scientific Adviser (Projects)
AUS(ER)	Assistant Under Secretary of State R & D Establishments and Research Administration
DCE	Deputy Controller R & D Establishments, Resources and Personnel
DCRP	Deputy Controller Research Programmes
HDS	Head of Defence Sales
MDROF	Managing Director Royal Ordnance Factories
DCDP(N)	Deputy Chief of Defence Procurement (Nuclear)
DGRA/CS (Navy)	Director General Research A/Chief Scientist (Navy)
DGRB/CS (Army)	Director General Research B/Chief Scientist (Army)
DGRC/CS (RAF)	Director General Research C/Chief Scientist (RAF)
DGRGen/ACSA(R)	Director General Research-General/ Assistant Chief Scientific Adviser (Research)

Fig.3 Procurement Executive – top-level organisation

The Service Departments are, amongst other functions, responsible for defining their requirements for new or modified equipments and for allocating funds for their procurement from the monies voted annually by Parliament for Defence. The Procurement Executive is then responsible for managing the procurement of the equipment within the money allocated. But this is after the procurement (that is, full scale development and production) of a particular equipment has been authorised by the Operational Requirements Committee and the Defence Equipment Policy Committee (Fig.2). These Committees are chaired respectively by the Deputy Chief of Defence Staff for Operational Requirements and the Chief Scientific Adviser, both of whom are members of the MOD Central Staffs.

Within the Procurement Executive (Fig.3) under the Chief of Defence Procurement (Sir David Cardwell) there are thus three Systems Controllers, namely, the Controller of the Navy, Master General of the Ordnance, and Controller Aircraft, who, broadly, manage the procurement programmes for their respective Services on allocations of money from those Service Departments. The Systems Controllers are also members of their Service Boards of Management as well as of the Procurement Executive Management Board. But the Procurement Executive also has funds allocated directly to it for other purposes of a more general nature, a major one of which is the maintenance of the Research and Development Establishments and the Research Programme. Responsibility for this lies with the Controller of Establishments and Research (CER), Sir John Charnley, whom you will meet this evening. He is also a member of all three Service Boards of Management, to provide the scientific input to their deliberations.

Within Sir John's Controllerate there are two Deputy Controllers, one for Establishments (DCE), responsible for allocation of resources, and the other for Research Programmes (DCRP) responsible for the balance of the Research Programme between subject areas and between in-house research and that which we pay contractors to do. Below DCRP are three Directors General of Research responsible, inter alia, for the research programme corresponding broadly to, respectively, the Sea, Land and Air Environments and one for matters of general balance overall. These posts are equivalent to two-star level, that is Rear Admiral and Major General. As you see, each of the three environment DGRs is also Chief Scientist of the corresponding Armed Service, and as such has other responsibilites, one of which is to act as the focus for the expression of Service priorities for research.

ORGANISATION OF THE RESEARCH PROGRAMME

The Research and Development Establishments of MOD have a variety of tasks (Fig.4), all of which depend on a sound research base but not all of which are funded within the research programme. For accounting purposes, we define research as work adding to the store of knowledge but not directly required in the development of an approved project. Thus, the costs of the last four items on this list are not accounted to research, although paid for out of CER's total annual budget. In very round terms, CER's total budget in terms of the total budget defence budget is around 4%. Of this 45% is spent on research and the rest provides for capital investment, in-house support for project development, etc. Of course, these other activities benefit research as well.

General research
Aimed research
Studies and assessments
Exploratory development
Technical support of approved projects
Acceptance of equipment for Service use
In Service support
Provision of test facilities at Trials Ranges

Fig.4 The role of the R & D establishments

For aerospace, the proportion spent on research is somewhat higher, because there is a lower proportion of direct involvement in approved project development.

Because research within a given subject area may be going on in more than one establishment, we have defined a number of broadly homogeneous subject areas, or Major Fields as they are called. The Major Fields associated principally with aerospace matters, together with the Establishments mainly concerned, are shown on Figure 5.

Each of these Major Fields is controlled by the Director, or a Deputy Director, of the R & D Establishment in which the majority of the work is done, the top one indicated in the righthand column against each Major Field. Each Major Field is divided into Research Areas, some of which I have indicated as examples, which broadly correspond to the research done in line management areas, such as the Research Departments at RAE, for example. Each Research area is further subdivided into work packages and work items. There are about 2000 work items in the research programme as a whole, of which roughly half are of direct relevance to aerospace.

The research is performed both intramurally inside the R & D Establishments and extramurally, in industry, universities and research associations. The allocation of funds to extramural research, within the total allocations given by MOD headquarters, has, since 1978, been the responsibility of Major Field Leaders and, under their direction, Research Area Leaders. This gives these officials the opportunity and the responsibility to align the work between intramural and extramural capabilities to achieve the best possible overall result on any piece of research.

MANAGEMENT AND FUNDING OF THE RESEARCH PROGRAMME

The management of the research programme for aerospace and its funding is a complex business. There are several customers for its output. First, there are the three Armed Services. Each of them establishes its priorities for research annually in some considerable detail and, as I mentioned earlier, it is one of my jobs as Chief Scientist (RAF) to take the lead in this part of the process. Where there is a degree of common interest across the three Armed Services, as, for example,

No	Title	Establishment(s)
1.	AIRFRAMES (Includes Aerodynamics,Airframe Structures,Materials, & Equipment)	RAE
2.	GAS TURBINES	NGTE
3.	ROCKET PROPULSION	PERME
7.	GUIDED AND AIR LAUNCHED WEAPONS	RAE ASWE RARDE RSRE
12.	ELECTRONIC DEVICES AND SYSTEMS (Includes Radar& Electro-Optical Sensors, Data Processing,Communications)	RSRE ASWE RAE
14.	NAVIGATION AND AVIONICS (Includes Flight Control Systems, Navigation,Weapon Aiming)	RAE
20.	SPACE	RAE

Fig.5 Major fields of research with aerospace subject matter and associated R & D establishments

in research for helicopters, we attempt to obtain a combined view of priorities. Funds for the research which results come directly out of the Defence budget.

But aerospace is not just a defence subject. Both the Department of Industry and the Civil Aviation Authority have need for research in various aspects of aerospace. Because the Defence R & D Establishments have the expertise and the facilities these other government agencies transfer funds fr[illegible]their budgets to MOD to pay for such aerospace r[illegible]ch as they need to perform their own functions

And finally, although not direct customers for the research programme's output, the industrial aerospace companies clearly have a strong interest in it. They may be directly involved, through MOD funding of extramural research, they may be doing complementary work funded by themselves or they may wish to follow up some piece of intramural research for commercial purposes.

Thus definition of the aerospace research programme has to take account of wider interests than just Defence. To help us sort out the needs, there is a variety of mechanisms (Fig.6). Formally, there are, in late Spring and early Summer, annual reviews of the past and projected programmes at Research Area and Major Field level. All government customers participate in these reviews which cover both intramural research activity and research funded by government extramurally. Subsequently, material from the Major Field Reviews is combined with information about the deployment of other CER resources, for example, in support of project development, into an annual CER Report to the Defence Research and Intramural Resources Committee in early December (see Figure 3). Each of the three Armed Services is represented on this Committee by its Vice Chief of Staff and the three Systems Controllers are also members; it is chaired by the Chief Scientific Adviser, Sir Ronald Mason.

Part of the job of this Committee is to agree overall policy for research, for example how much of overall resources should be devoted to basic research, what general subject areas ought to receive highest priority for research and so on. The Chief Scientific Adviser then reports on such matters to the Chiefs of Staff Committee and to Secretary of State for Defence.

Supporting these formal review activities we have for aerospace research instituted in the last few years a system of Research Consultative Committees. Each of these covers a Research Area and provides a forum for discussion of the whole research scene in that Area, both Government and privately, that is, industry, funded. This enables the research to be seen from the point of view of "UK Limited", and helps industry to plan its privately funded work in the light of official intentions and helps the R & D Establishments to avoid undertaking work on aspects already being covered by industry.

These Research Consultative Committees have no executive authority, they are purely advisory, but both sides have acknowledged their great value in planning research to avoid duplication and to make best possible use of available research resources.

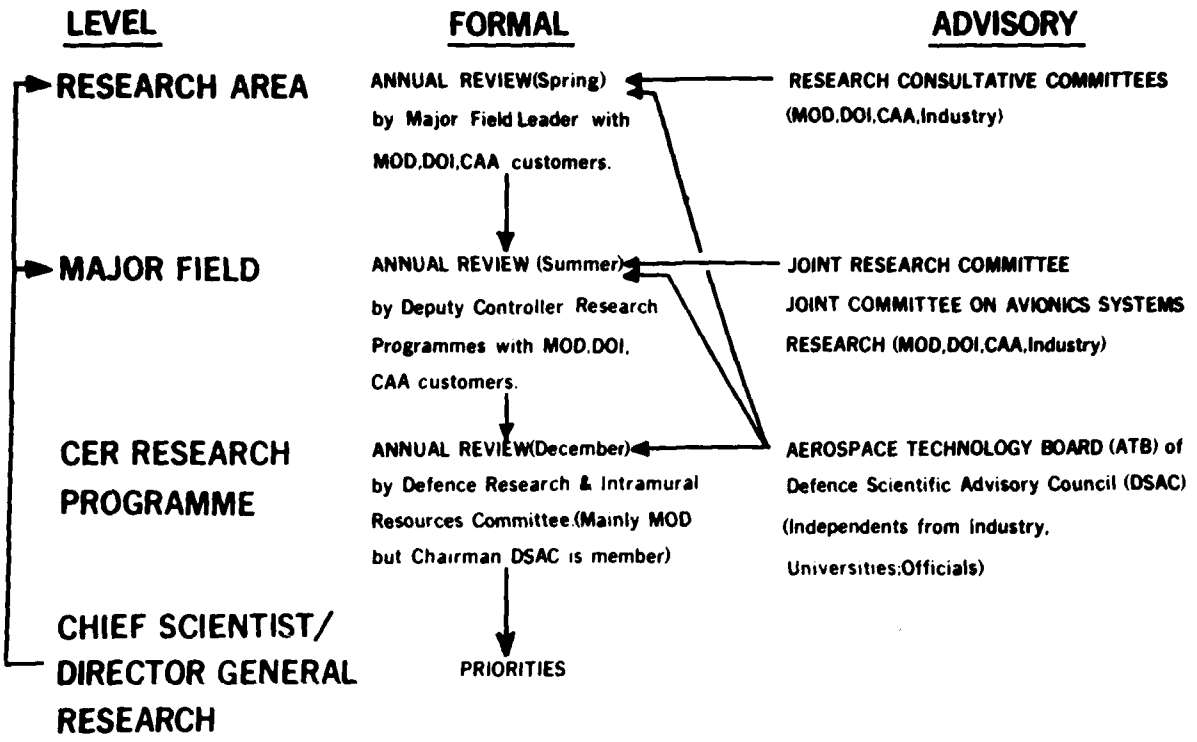


Fig.6 The research programme review process for aerospace

Two further government/industry advisory committees, the Joint Research Committee, which covers broadly airframe and propulsion matters, and the Joint Committee on Avionics Systems Research take a broader look at the balance of work between the Research Areas and eventually across the Major Fields and advise CER headquarters accordingly. This allows industry to make its views known at the highest level on the balance and direction of aerospace research, and I can assure you they do so in no uncertain terms!

Finally, to make available other sources of expert advice, the MOD has set up the Defence Scientific Advisory Council (DSAC). This is chaired by an eminent independent scientist, generally from a University. The Chief Scientific Adviser and the Controller of R & D Establishments and Research, CER, are members but the main membership is drawn from universities and industry, and the members serve as independents rather than representatives.

The DSAC has a number of Boards, including an Aerospace Technology Board which has to some extent replaced the late Aeronautical Research Council. The current Chairman of the Aerospace Technology Board is Professor L.F.Crabtree of Bristol University, whom some of you already know and who will be present at our dinner this evening.

The role of the Aerospace Technology Board is broadly to provide Her Majesty's Government with a source of independent advice on aerospace research, from the points of view of both the kinds of problems which should be the subjct of research and the solution of problems which have been identified as posing particular difficulty.

Gentlemen, in fifteen minutes I fear I may have only succeeded in confusing you about what, in typically British fashion, we do in order to try to reach a balanced consensus view of research issues and the content of research programmes and to avoid duplication. I will now hand over to Dr Rogers, who will tell you briefly about the nature and scope of our UK aerospace research programme.

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DR E.W.E.ROGERS, United Kingdom National Delegate

Thank you. You have heard from Mr Harper how research in the United Kingdom is organised and funded. I would like to talk briefly about the research itself and its range. The time available is far too short to cover all that is being done, so I can only provide an outline, which must be incomplete.

First, where is aeronautical research done in the United Kingdom? The main contributions come from the Ministry of Defence Establishments, the Industry, and the Universities. The Royal Aircraft Establishment (RAE), which employs about 6000 people, is the designated centre of UK research activity on aircraft, aircraft equipment and weapons. Farnborough, seen on Figure 7, is the main RAE centre but there are large missile test ranges in the west, and numerous smaller sites for work on such topics as space, communications, parachutes and sonobuoys. Most of the flight research as well as the major RAE wind tunnels are located at Bedford.

Other important UK sites are the National Gas Turbine Establishment (NGTE) and the Institute of Aviation Medicine, both close to RAE Farnborough, which is the centre of research on engines, and the Aircraft and Armament Experimental Establishment at Boscombe Down near Larkhill, whose prime task is the flight clearance of aircraft and their equipment, a task which involves them with the research scene. The Royal Signals and Radar Establishment (RSRE) at Malvern is important too, covering as it does topics like airborne radar. Controller, Establishments and Research, of the Ministry of Defence is also responsible for work needed by the Army and the Navy, and thus has many other specialist research establishments, for example the Royal Armament Research and Development Establishment at Sevenoaks in Kent and the Admiralty Marine Technology Establishment, which has a number of sites. For some topics, and materials is a good example, there are strong connections between these organisations and places like RAE and NGTE.

The aeronautical industry plays an essential research role. British Aerospace (BAe) at its several sites throughout the UK covers a wide range of subjects. Westland Helicopters at Yeovil also makes a strong research contribution. Then there are the big electronic firms, Marconi and Ferranti for example, and major equipment manufacturers like Lucas and Dowty-Rotol; and the main materials suppliers (Delta Metals and Courtaulds, for example). All these have large programmes of private research (usually called private-venture or 'PV' research in the UK) as well as research funded by MOD and the Dept of Industry (DOI).

Finally, there are the Universities, who undertake research paid for by Industry, by the UK Science and Engineering Research Council, by the Ministry of Defence or the Department of Industry. RAE alone manages about 150 research agreements with British Universities, including some at Oxford.

Generally speaking, the Universities concentrate on basic research, activity which adds to our understanding as to how nature works, whether this is fluid dynamics, metal-crystal structure or the physics under-pinning electronic devices. The Government Establishments are involved with both basic research, particularly if this requires apparatus or manpower beyond that normally available to the Universities, and with applied research whose prime objectives are to improve existing aircraft, weapon, or equipment performance, and to provide data and understanding which will aid the next generation of projects. Industry is concerned mainly with applied research, linked to existing or new projects. This categorisation is only an approximate one and there are overlaps between the work done in Universities, Establishments and Industry; this is good, because the interconnections between the three types of organisation become even stronger.

As has already been said, research sponsored by MOD and DOI is split up into a number of Major Fields. This morning I have only time to talk about three of these and then only briefly. These are Major Field 1, which is concerned with aerodynamics, structures, materials and some non-electronic equipment (as it happens this is my particular responsibility); Major Field 2, which deals with engines; and Major Field 14 within which work is done on the wide range of problems and equipment needed to improve flight behaviour and navigation. There are other research Major Fields which bear on the aeronautical scene, but I will not mention these further except to say that Major Field 7, for example, brings together work on weapons, including ways to carry and release them efficiently, and Major Field 12 which deals with electronic systems, including radio communications.

Major Field 1 has an aerodynamics sub-field. Successful aerodynamic research, whether basic or applied, demands access to large wind tunnels. Industry has its own, here at Warton for example, and at the Aircraft Research Association near Bedford. The main RAE tunnel site is also near Bedford, where there are several major facilities.

Fig.7 RAE Farnborough

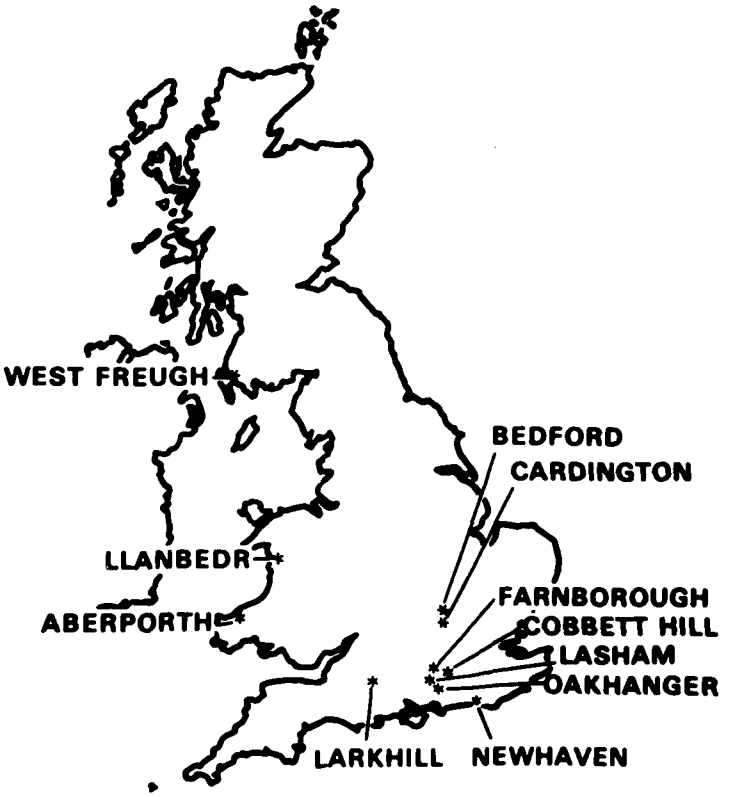


Fig.8 RAE Farnborough & outstations

AIRFRAMES, WEAPONS	BRITISH AEROSPACE WESTLAND HELICOPTERS	SHORTS
EQUIPMENT	LUCAS	DOWTY ROTOL
AVIONICS	PLESSEY EMI FERRANTI	MARCONI SMITHS
MATERIALS	ALCAN DELTA METALS	ICI COURTAULDS
ENGINES	ROLLS ROYCE	

Fig.9 Examples of research in UK industry

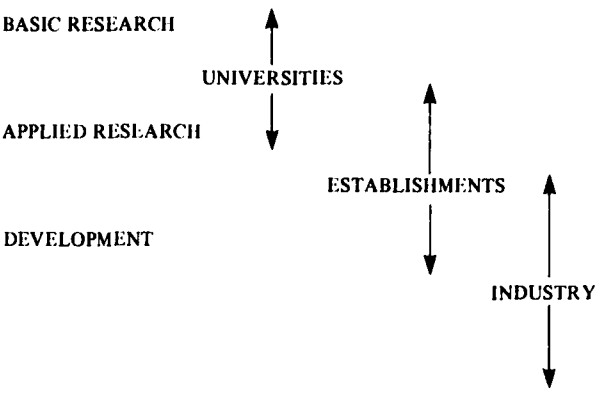


Figure 10

MF1	AERODYNAMICS, STRUCTURES, MATERIALS AND ENGINEERING
MF2	POWERPLANTS
MF7	GUIDED AND AIR-LAUNCHED WEAPONS
MF14	NAVIGATION AND ELECTRONICS

Fig.11 Major Fields of UK research in aeronautics

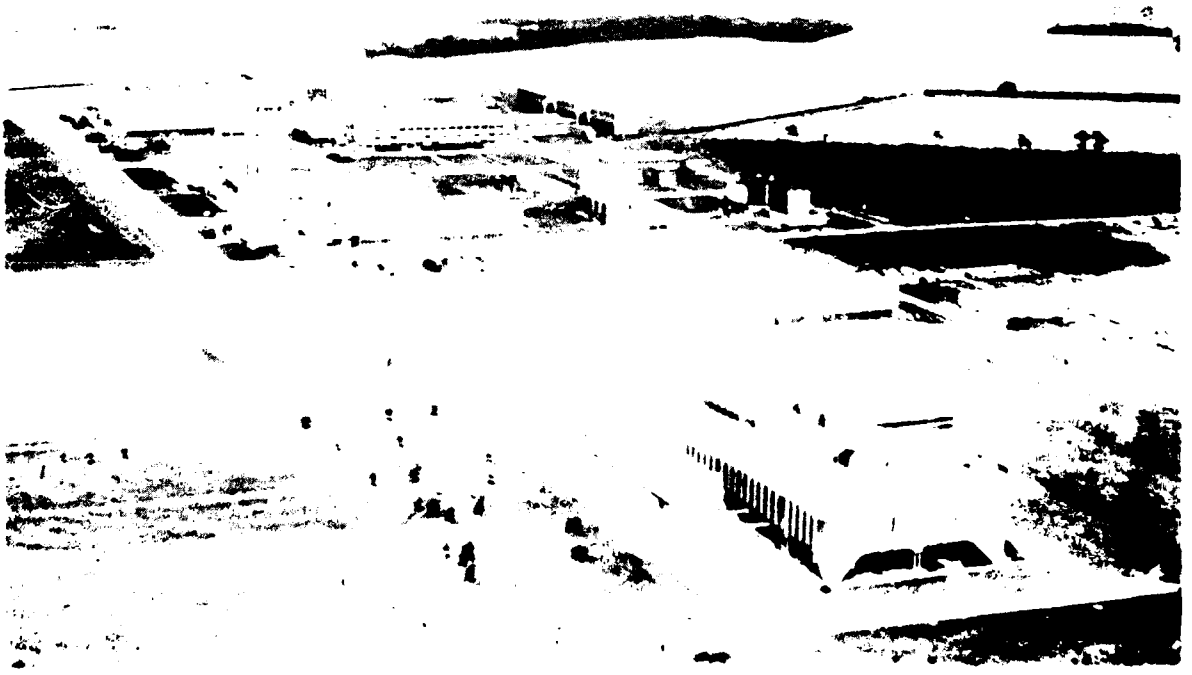


Fig.12 RAE Bedford

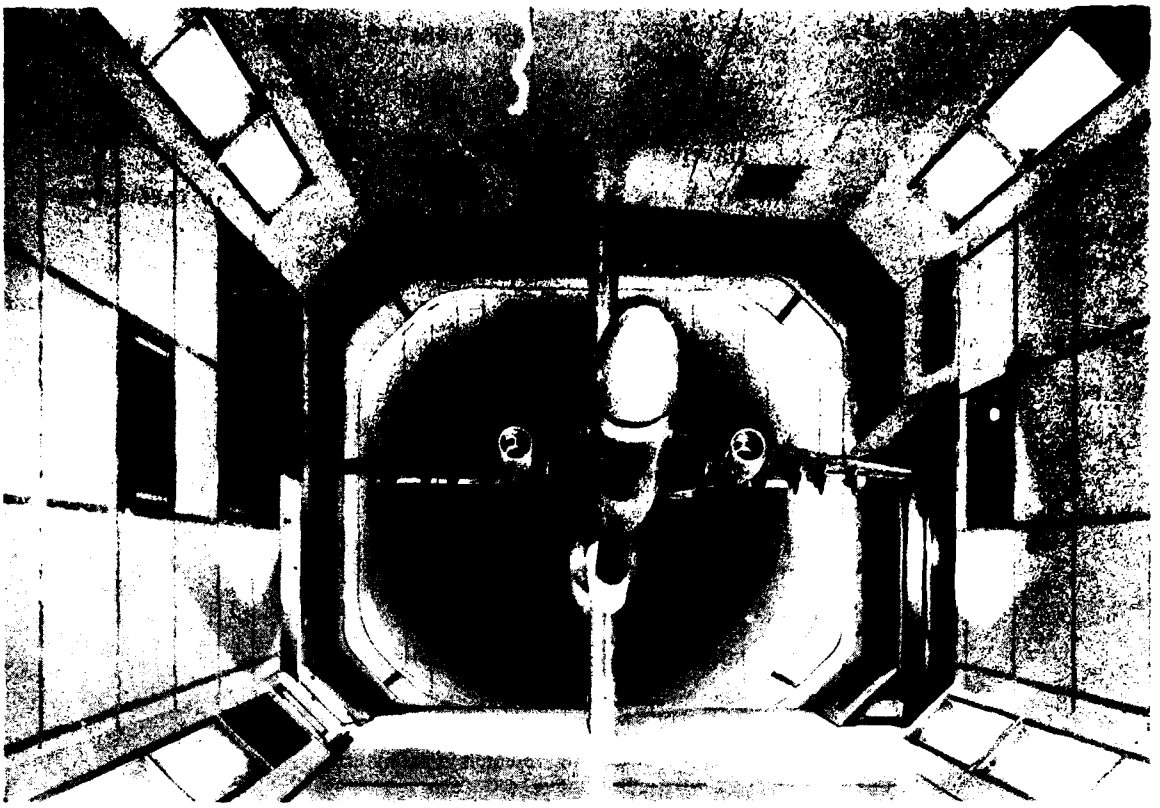


Fig.13 Farnborough 5-metre low-speed pressurised wind tunnel

The new 5 m low-speed pressurised tunnel however is at Farnborough, and is extensively used for work on military and civil high-lift systems. Within the aerodynamics programme there is a strong emphasis on basic fluid mechanics (boundary layers, flow separations, the use of big computers to calculate transonic flows). As you might expect, the Universities contribute well in this area.

Current military emphasis is on efficient, manoeuvrable wings, on the problem of weapon carriage (where there are significant performance and accuracy gains to come from better weapon installation and grouping), on the aerodynamics of vertical and short take-off and landing and on aircraft stability and control, especially at high incidence. Helicopter rotor performance has made large strides in the last decade, thanks to advances in the aerodynamics, and also the dynamics of rotors. Helicopters thus form an important interface between the two subfields of aerodynamics and structures. Noise and vibration is another such topic. How does it arise? How is it transmitted through the airflow about the aircraft and through the structure? Such questions lead us to research on structural dynamics, a topic whose importance, always large, has been additionally heightened by the drive towards employing active controls for aircraft.

In addition there are two major topics which bridge the boundary between structural and materials research. Of great practical significance in keeping older aircraft flying or in designing new ones with longer lives, is the subject of fatigue and fracture mechanics, and accordingly there is a very strong effort on this topic at RAE, in BAe and in the Universities. We must under-

BASIC FLUID MECHANICS

HIGH-LIFT SYSTEMS

WING DESIGN

WEAPON CARRIAGE & RELEASE

STOVL AERODYNAMICS

STABILITY & CONTROL AT HIGH INCIDENCE

HELICOPTER AERODYNAMICS

NOISE

Fig.14 Aerodynamics topics

HELICOPTER DYNAMICS

VIBRATION AND STRUCTURAL DYNAMICS

FATIGUE AND FRACTURE MECHANICS

METALLURGY OF STEELS, ALUMINIUM & TITANIUM ALLOYS

NON-DESTRUCTIVE TESTING

CARBON COMPOSITES; GLASS COMPOSITES

WEAR & CORROSION

ELASTOMER, SEALANTS, ADHESIVES, RUBBERS

VULNERABILITY AND DAMAGE REPAIR

Fig.15 Structures and materials topics

stand the basic mechanics that underlie the initiation and growth of cracks in aluminium and titanium alloys and also in steels, and their ultimate failure. Using the latest methods of structural analysis we need to develop ways of estimating and increasing the residual strength of cracked structures. From work in physics, metallurgy and computer data-processing we can arrive at new or improved non-destructive testing systems. The second major area is that of composites, particularly carbon-fibre composites, invented incidentally at the RAE. You will hear more about this subject later to-day. Let me just say that successful structural applications of carbon-fibre composites must be underpinned by a sound knowledge of materials science.

The range of UK work on materials is diverse. Our attack on basic metallurgy helps towards new alloys, towards more cost-effective fabrication techniques (say, for titanium components), in evolving high-strength steels for helicopter gears. And we must work on wear and corrosion. But in the UK programme there is also much activity aimed at non-metals, so essential for keeping aircraft flying safely – plastics, elastomers, sealants, adhesives, rubbers, fabrics. The influence of a harsh climate (hot or cold, and wet) on these materials is particularly important. I have dwelt perhaps disproportionately long on the materials area, but its diversity (and hence the range of scientific skills) is not always appreciated, nor sometimes is its importance to modern aeronautics. I have left no time to mention research on fuel systems, on aircraft vulnerability, on damage repair and escape systems which form part of the engineering sub-field.

Thus Major Field 1, with its combined attack by RAE, Industry and the Universities, embodies the major thrust by Government-funded work in the UK on the airframes of combat and transport aircraft, helicopters and weapons. The programme evolves, through regular meetings between all parties at both strategic and working level. However the problems to be tackled are formidable and despite the significant forces we are able to deploy, resources are always fully stretched and progress is sometimes slower than one would wish.

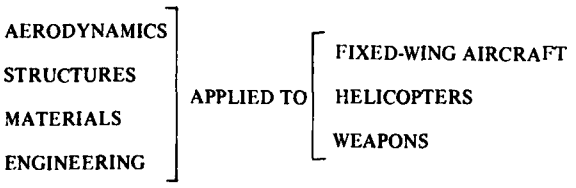


Fig.16 Major Field 1

Let us turn briefly to Major Field 2, where there is a strong combined effort by NGTE and Rolls Royce. This Major Field covers all aspects of engine design and performance, together with the problems that arise when the engine is installed in the aircraft. This is an interesting interface. The engine man talks of "installation drag' and blames the aerodynamicist, who prefers to speak of 'a loss of engine thrust'. Hence combined work on efficient engine installations for military or civil aircraft is a prime task. NGTE and Rolls-Royce have made great strides in understanding, predicting and

ENGINE INSTALLATION PROBLEMS

FAN, COMPRESSOR & EXHAUST NOISE

FANS, TURBINES AND COMPRESSORS

HIGH-TEMPERATURE MATERIALS

CREEP, FATIGUE & CORROSION

COMBUSTION & FUELS

ENGINE CONTROLS

Fig.17 Major Field 2: powerplants

reducing engine noise. Most of the individual sources of noise have been located and progress in improving these has been helped by the existence of the impressive Noise Test Facility recently built at NGTE. For engine design, research is aimed at improving the performance of all gas-turbine components, particularly fans and compressors. Improved blade cooling is a major factor in increasing engine thrust and blade life, and reducing fuel consumption. Associated with this must be work on high-temperature materials and a study of topics such as creep, thermal fatigue and corrosion. There are thus links to work on similar topics within the airframe Major Field. Engine efficiency is also related to combustion, which for the gas turbine is a complex mixture of fluid dynamics, thermodynamics and chemistry, and with this is linked the important subject of emission control. All this work requires many specialist rigs, including major Test Cells (the one in Figure 18 is at NGTE) to provide the final practical assessment of engine behaviour. The UK has a large and successful engine industry and thus requires the strong and flexible research attack embodied in Major Field 2.

Effective modern aircraft and weapons however demand more than good aerodynamics and structures and efficient engines. They must have predictable flying qualities, precise control, accurate navigation, and for aircraft, a cockpit that enables the pilot to perform what is often a very complicated task in the best possible manner, Major Field 14 (Fig.19), the last of the MFs I wish to touch on, covers a wide spread of work, contributed to by Industry and the Universities, RAE and RSRE. It is concerned with basic research and also with systems, with avionics and their integration into overall aircraft operational systems whether civil or military. It deals with the pilot as part of the control loop, as a link in the effectiveness of the military machine. It thus needs psychiatrists and physiologists, as well as physicists.

In place of the wind tunnel of MF1 and engine test cell of MF2, we now have the simulator. There is a large motion flight-simulator complex at RAE Bedford, currently undergoing improvements, a number of combat and other simulators at Farnborough, and excellent equipment here at Warton. These explore pilot behaviour, control laws and the effects of gusts on flying qualities, as well as the aircraft and weapon characteristics that achieve success in combat or weapon delivery. Major Field 14 includes work on navigation equipment, on the systems needed for advanced active-control designs (again part of this work is being done here at Warton), and on equipment that enables

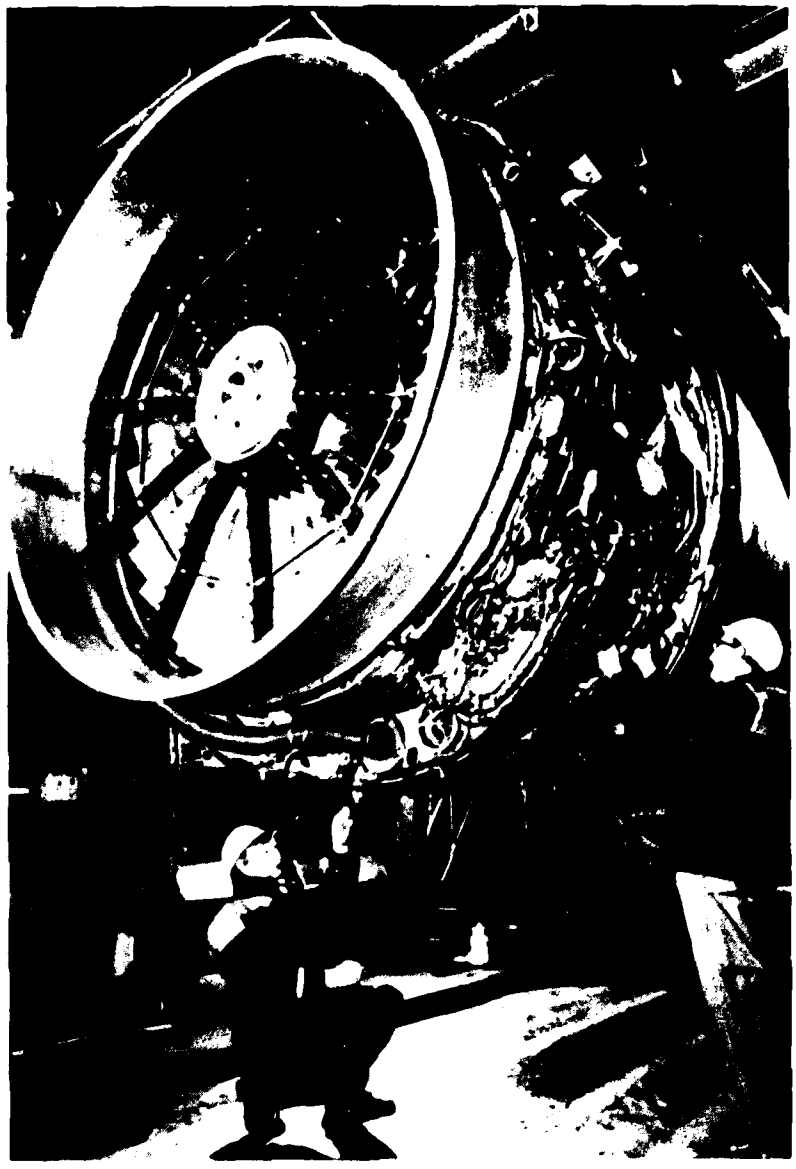


Fig.18 Engine test cell at National Gas Turbine Establishment

PILOT AND CREW BEHAVIOUR AND PERFORMANCE

FLIGHT CONTROL

WEAPON AIMING AND TARGET ACQUISITION

NAVIGATION

COCKPIT DESIGN, INSTRUMENTS & DISPLAYS

AIRCRAFT AVIONICS

THE MANAGEMENT OF AIR TRAFFIC

LANDING GUIDANCE

Fig.19 Major Field 14: navigation & electronics

helicopters and fixed-wing aircraft to operate successfully in the battlefield.

Let me stress again the combined nature of the UK research attack (Establishments, Industry, Universities); its depth (from fundamental research to work with strong project applications); its range (from the aerodynamics of engines to the psychology and physiology of pilots); the closeness of its coordination, extending over many hundreds of research workers responsible for tens of millions of pounds of annual spend, and several hundred million pounds of capital investment. Our aim is to provide a strong and practical research basis for the UK's industrial and operational needs. Our contribution to AGARD can then be wide-ranging and authoritative. On our National Day only a small part of the research scene can be covered and so we have chosen to bring you to BAe Warton, to see something of one site's contribution, one part, but an integrated part, of the national effort.

Welcome to Warton!

Home of the Warton Division of British Aerospace's Aircraft Group. In fact, Warton airfield, where the AGARD National Delegates landed after their flight from RAF Brize Norton, is one of three major centres which comprise the Division. The others are fairly close by, at Preston and Samlesbury. For over a quarter of a century now, military aircraft, both subsonic and supersonic, have been designed, developed, and built here. And as was explained by Mr Harper in his introductory presentation to the visitors it was precisely because of this wealth of experience and the wide range of aerospace research and technology work in which Warton is involved that the National Delegates were invited here on the UK National Day.

Mr R.Dixon, BAe's Divisional Research Director, who followed the MOD speakers, set the background for the afternoon's tour of the laboratories, assembly line, etc., and we reproduce below part of his presentation in the hope that it provides something of the atmosphere of the occasion.

WELCOME ABOARD for AGARD Chairman, Dr Alan M.Lovelace (centre) from Mr S.Gillibrand, Deputy Managing Director, British Aerospace, Warton. On the right is Mr R.Dickson, the BAe's Divisional Research Director at Warton.

Good morning, Gentlemen. Welcome on behalf of British Aerospace. I would first like to show you where we fit into the general Corporate structure. Figure 1 shows the locations of the Aircraft Group and Dynamics Group Divisions. The Warton Division has 19 thousand employees spread between three sites (Warton/Preston/ Samlesbury) and including several thousand in Saudi Arabia on our support activity.

Figure 2 shows the general organisation. The left-hand side is the Aircraft Group of Divisions, the right-hand side is the Dynamics Group. Warton Division, shown bottom left, is the largest Division in British Aerospace.

It would probably be useful to those of you who are not familiar with our history in this location, if I show

you our products over the last thirty-five years. The first of these was the Canberra (Fig.3) which was also built under licence in the USA as the B57.

Then we have the Lightning, a supersonic fighter (Fig.4) followed by the Jet Provost and Strikemaster (Fig.5).

Our first international collaborative project was the Jaguar (Fig.6), starting in 1965, designed and built in partnership with France, and now selling on the export market. Our current major project is the tri-national Tornado (Fig.7) built in partnership with Germany and Italy, and this is now well into its major production series run. We are of course working on future projects beyond Tornado.

One point I would like to emphasise about Warton (Fig.8) is that it is one of the few places in this country where one can see almost the whole spectrum of activity, through Research, Design, Development, Laboratory Testing, Final Assembly of aircraft and Flight Testing. This leads to an efficient use of resources. On this site we have a wide variety of test laboratories, including two low-speed and one high-speed wind tunnels, structural and material test laboratories, and mechanical and avionic system test laboratories.

You will only be able to see some of these facilities on your tour this afternoon, as time is limited, but I trust you will enjoy the visit and find it stimulating.

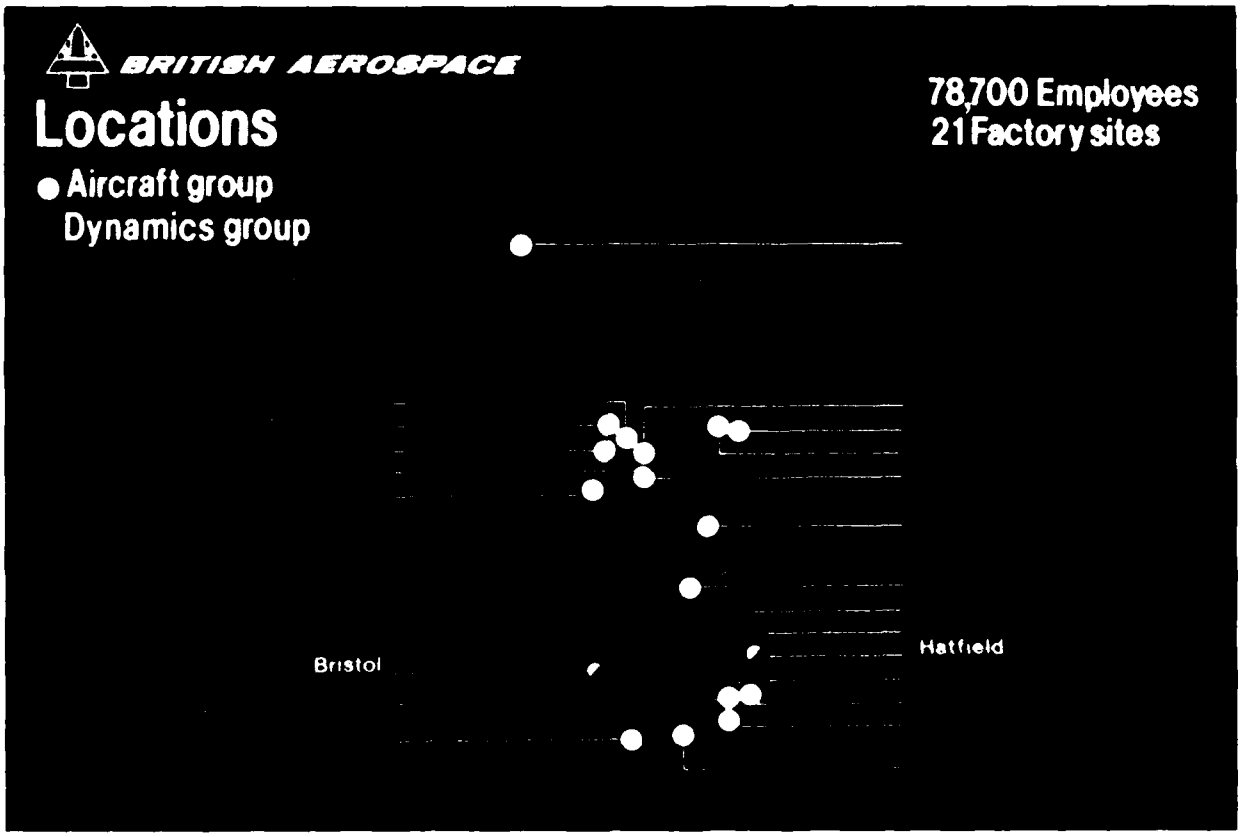


Figure 1

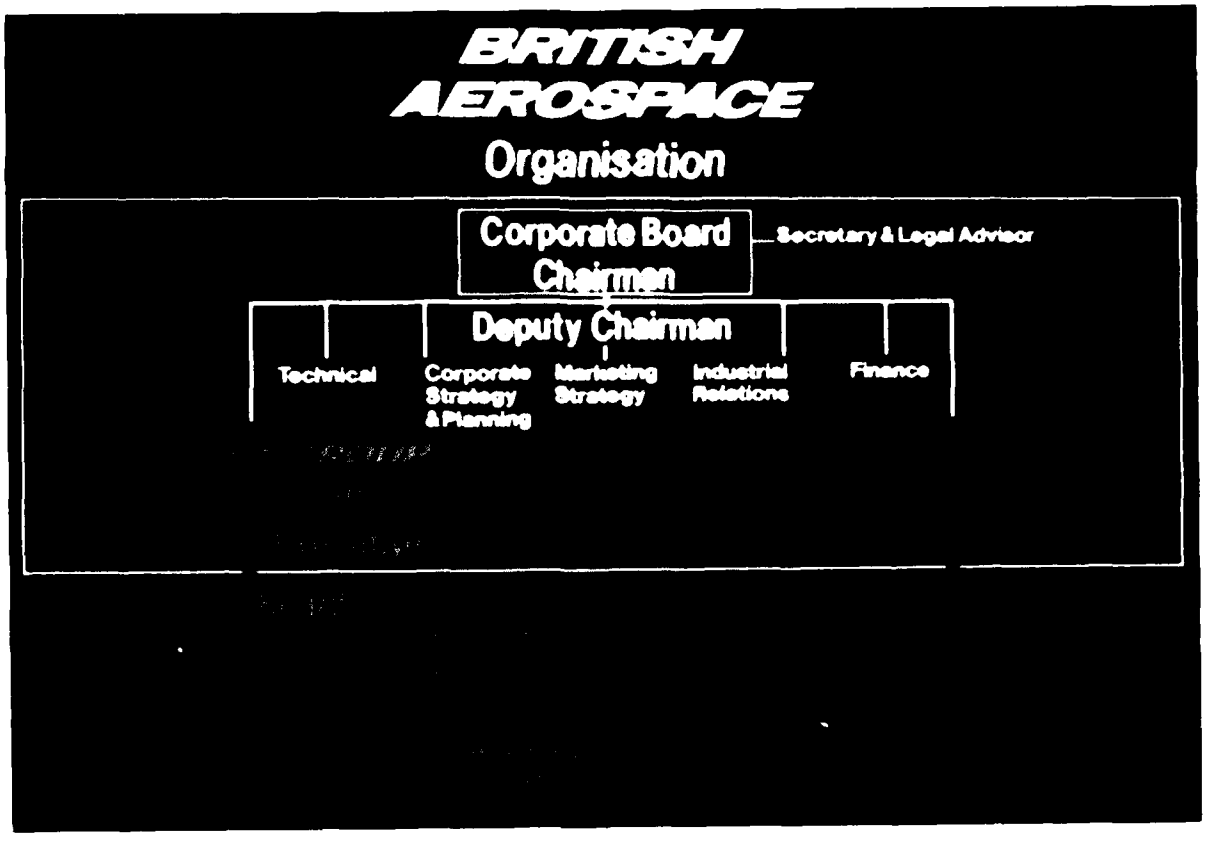


Fig.2 British Aerospace Organisation

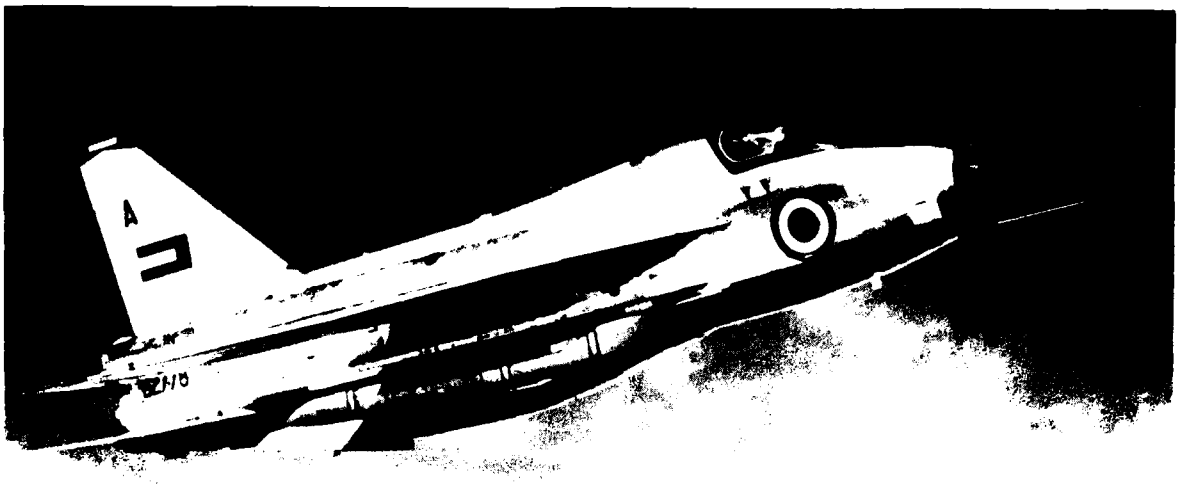
1376 TOTAL NEW AIRCRAFT BUILT

925 UK BUILT OF WHICH 146 EXPORTED
PLUS 95 RE-BUILT AND EXPORTED

451 LICENCE BUILT

IN SERVICE WITH 15 AIRFORCES

Fig.3 Canberra

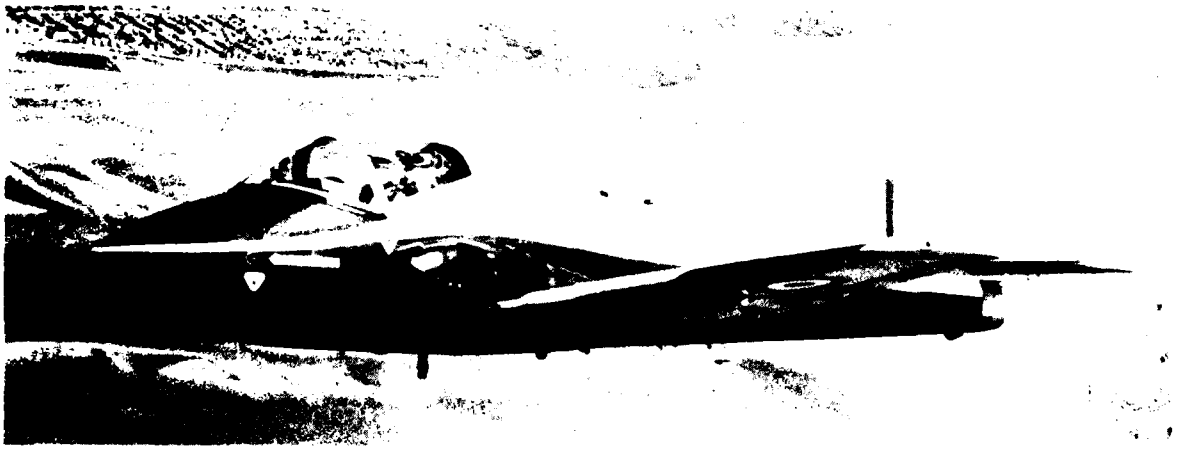


339 TOTAL MANUFACTURED

61 EXPORTED

IN SERVICE WITH 3 AIRFORCES

Fig.4 Lightning



729 TOTAL MANUFACTURED } OF WHICH 145 WERE STRIKEMASTERS

219 EXPORTED }

IN SERVICE WITH 13 AIRFORCES

Fig.5 Jet Provost/Strikemaster

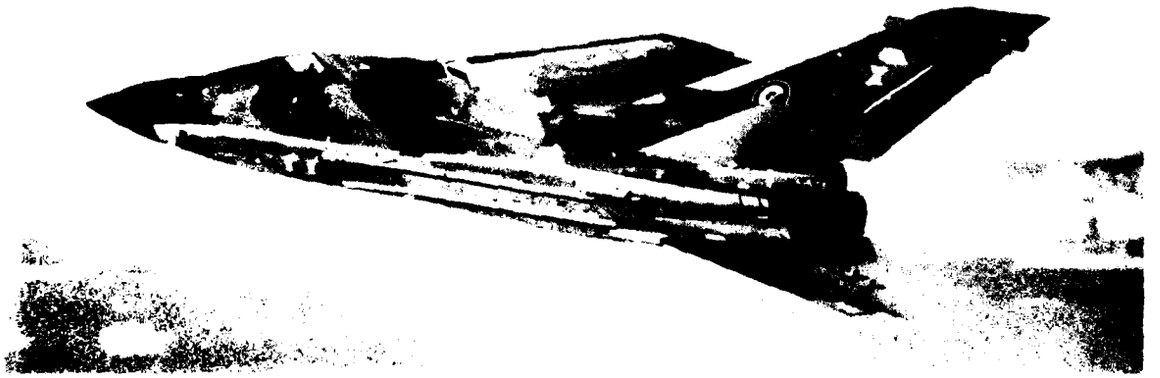
479 TOTAL ORDERED

110 TO BE BUILT UNDER LICENCE

416 DELIVERED

IN SERVICE WITH 5 AIR FORCES

Fig.6 Jaguar



WILL BE IN SERVICE WITH 3 AIRFORCES

809 INTERNATIONAL PROGRAMME

385 UNITED KINGDOM 324 GERMANY 100 ITALY

Fig.7 Tornado

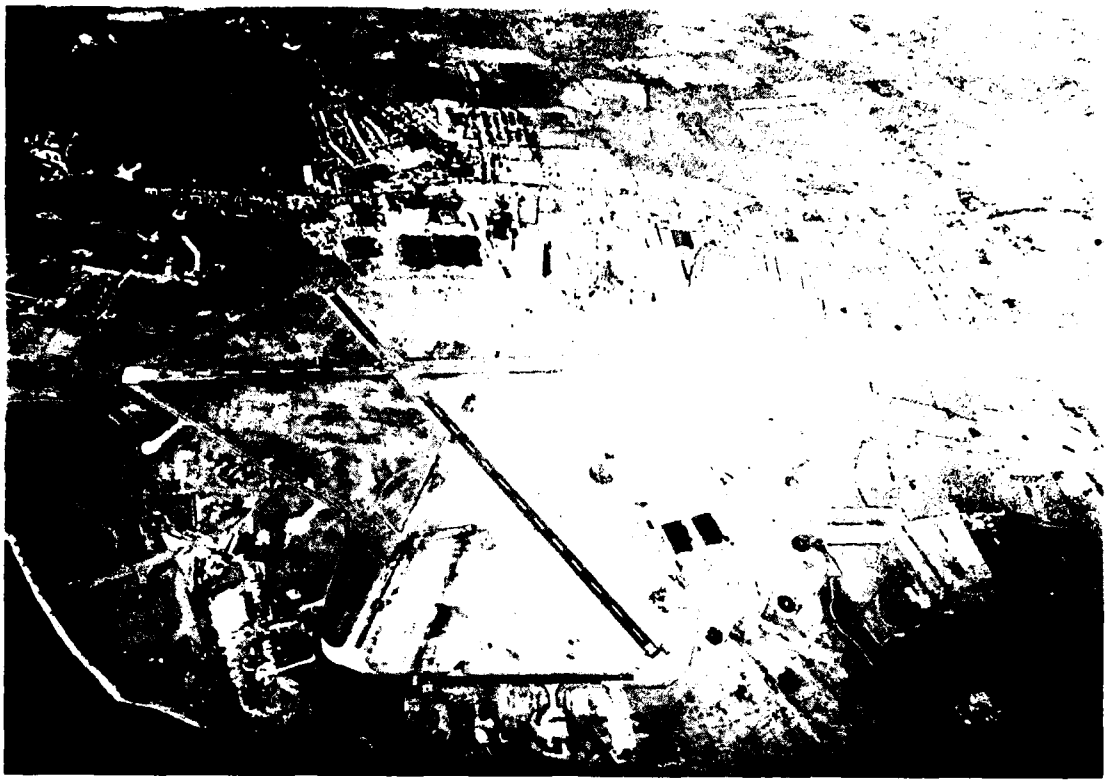


Fig.8 Warton

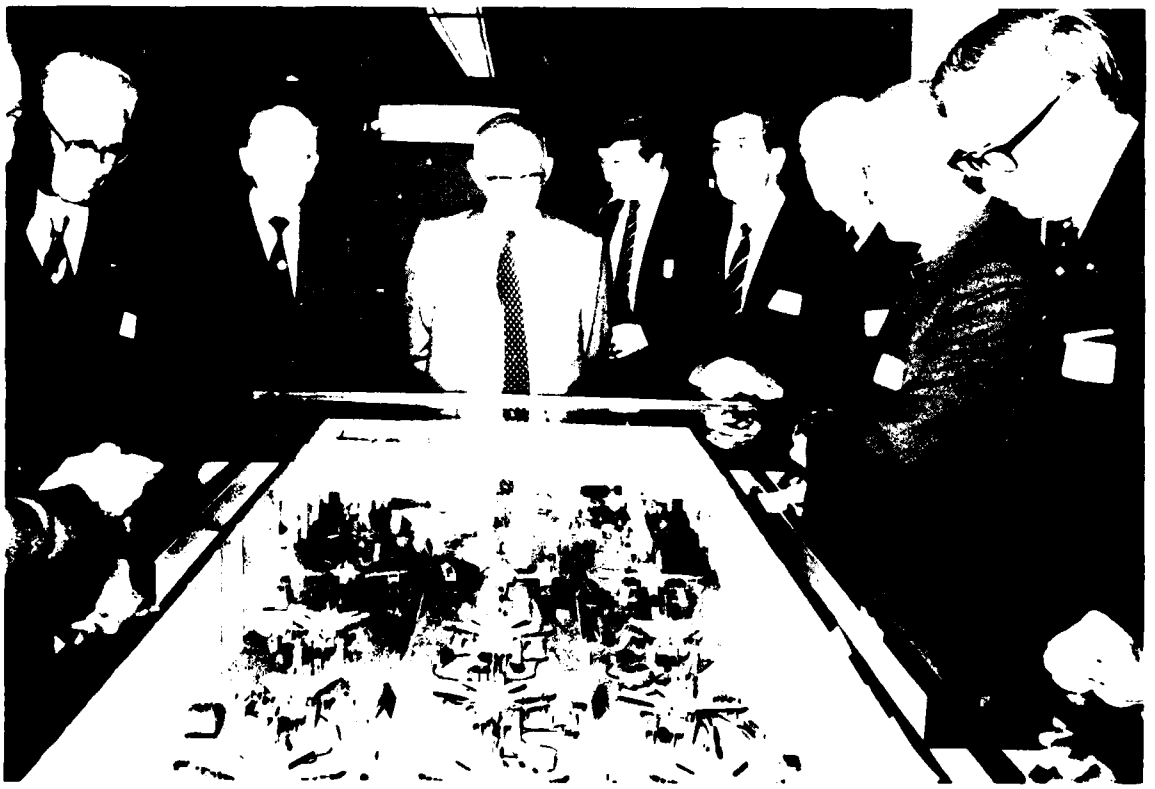


Fig.9 Warton facilities tour. One of the visiting groups view the Tornado production hanger layout

UK NATIONAL DAY, 1981

WOLFSON COLLEGE DINNER

OXFORD, ENGLAND

In the evening of Thursday, 17 September 1981, following their visit to the British Aerospace facility at Warton, the AGARD National Delegates dined together in Wolfson College, Oxford, with the kind permission of the President of the College, Sir Henry Fisher. Host and principal speaker for the occasion was Sir John Charnley, representing the UK Ministry of Defence, himself an erstwhile National Delegate to AGARD and hence well-known to many of those present. Following is the text of Sir John's after-dinner speech, interspersed with photographs taken at the Reception beforehand.

* * *

UNITED KINGDOM HOSTS for the Dinner at Wolfson College, Oxford, were Sir John Charnley, Controller of Establishments and Research in the UK MOD, and his wife. Sir John is here seen with Mrs Maunder and Mr Maunder, the Vicegerent of the College

I am very pleased that the Annual Meeting of AGARD is, for the third time being held in the United Kingdom, and in the pleasant environment of a famous University City. The first occasion was the 3rd General Assembly in London in September 1953, the next occasion was an Annual Meeting in 1968 held (dare I say it!) at Kings College, Cambridge, a university which is sometimes referred to by Oxford men as 'that other place'.

It is a happy coincidence that today happens to be the birthday of Sir Isaac Wolfson the founder of this splendid college, adding an additional touch of celebration to our dinner this evening. Sir Henry Fisher, the distinguished President of Wolfson College and Lady Fisher, who so very kindly entertained the AGARD ladies yesterday are unfortunately unable to be with us but I am delighted to welcome Mr Maunder the Vicegerent of Wolfson College, and Mrs Maunder, and I would be grateful Sir, if you would convey to Sir Henry Fisher our gratitude for the use of these fine buildings for this occasion.

Next, I would like to extend the warmest of welcomes to the many distinguished scientists and engineers from the NATO countries who have made the journey to Oxford. Looking round the hall it is good to see so many faces familiar to me from my past AGARD and other international connections. In preparing my talk I originally intended to mention particular friends

by name but the list soon became too long so through you, Chairman, I would say to you all, on behalf of the Ministry of Defence, that you are most welcome to the United Kingdom for this meeting. I am only sorry that Dr Wattendorf, who was the Director of AGARD when I first met him in 1954, is unable to attend as I know how he still likes to take an active interest in AGARD proceedings. You have, I know, a very busy programme, but I trust you will have some time to relax and see something of the beauty of Oxford and its colleges, taking away pleasant memories of your visit. I am also delighted that so many of your wives are able to join us this evening. I understand that they now form one of the largest groups of experts on stained glass ever seen in Oxford, and they must certainly be the most attractive.

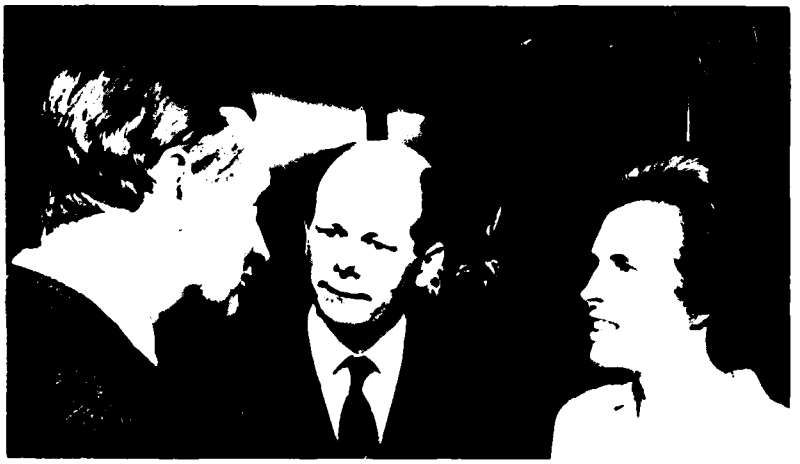
I am also happy to welcome several guests and their wives from the United Kingdom Air Marshal Hine, who recently addressed the Flight Mechanics Panel during their very successful VSTOL Symposium in Paris; Professor Crabtree, who is the Chairman of our Defence Scientific Advisory Council Aerospace Technology Board, and Mr Kerr, the Director of the Royal Aircraft Establishment at Farnborough. Regrettably, Mr Ivan Yates of British Aerospace cannot be with us, but I should mention that he very kindly agreed that his company would host our National Day programme and also provided the air-lift which made it possible.

My own association with AGARD goes back almost 30 years when I worked with two of the first four panels, the Flight Test and Instrumentation Panel and the Wind Tunnel and Model Testing Panel and I recall contributing to one of the early AGARDographs on "Transonic Flight Testing and Instrumentation". In 1954 I took part in a round table discussion on the 'Subjective Experience and Reactions During Flight Testing in the Transonic Region'. Dr von Kármán was the Moderator and well-known test pilots of the day, Cdr Carpentier, Sqn Ldrs "Spud" Potocki and Neville Duke, Major Chuck Yeager and Mr Scott Crossfield (NACA), described the interesting and sometimes hair-raising experiences they encountered in trying to fly aircraft through the transonic region. It makes one realise what giant strides have been made in the last quarter of a century when you consider that shortly a similar discussion might centre on the handling of the Shuttle during re-entry from space. And then much later, from 1975 77, I spent two very enjoyable years as United Kingdom National Delegate, under the watchful eye of Al Flax a daunting experience.

The United Kingdom has always played a significant role in AGARD since its foundation in 1952. In addition to our regular and continuous contributions to the membership of Panels and the Administrative Bodies, we have been called on to provide specialists to serve on Ad Hoc Groups or as Consultants. We have tried whenever possible to put our knowledge and experience at the disposal of AGARD, knowing that in so doing we are contributing to the strong scientific backing which the NATO military authorities clearly regard as of vital importance. During the last year we have hosted a GCP Panel Meeting and Symposium, a meeting of the AASC, two lecture series, and a very-well-received lecture by Seth Anderson on the "Problems of Aircraft Control" which was so graphically illustrated by a film of aircraft losing control that it was rumoured that some people contemplated cancelling their flights home to go by train and boat instead!

As I think you heard today at Warton, there have been many changes in the United Kingdom's organisation and management of defence research over the past decade. Besides the changes within the Ministry of Defence, there has been an increasing involvement of industry and the Universities, not only in conducting research but also in detailed discussion on the content of our research programme. But despite the upheaval of these many organisational developments, I believe that the quality of aerospace research as a whole in the UK has been sustained and also, as I indicated a moment or two ago, we have continued to maintain a lively participation in AGARD. You saw today some typical examples of current research and I trust you found the presentations and demonstrations both interesting and informative.

I understand that tomorrow you will be considering the commissioning of a Study into "AGARD in the



AIR VICE MARSHAL HINE, Assistant Chief of the Air Staff (Policy) and his wife talking with Trevor Wilcock (centre), Flight Mechanics Panel Executive, who will leave AGARD shortly to resume his duties with the UK MOD

Mr T.H.KERR, Director of the Royal Aircraft Establishment Farnborough, UK

MR G.C.HOWELL, Head of RAE's Flight Systems Dept and presently AGARD Guidance and Control Panel Chairman in conversation with two members of the Working Group on "AGARD in the 1980s and Beyond", Mr C.Baron (UK) and the Group's Chairman, Prof. J.Walsh (US)

1980s and Beyond" to be led by Professor Walsh. I am sure we would all agree that AGARD has a wealth of achievements to its credit stemming from its Charter, laid down over 25 years ago. But I am equally sure that the time is ripe for consideration of its future role particularly in the light of current and future trends. Before saying a word on my personal view of some of these, there is one particular aspect of AGARD I have always valued highly, and that is the opportunity it affords to establish lasting friendships, and hence fruitful working relationships, with colleagues in other NATO countries. It is not easy to attach a financial tag to these links but time and again they have eased official negotiations between the nations and helped to establish a deeper understanding between the military staffs and ourselves. I believe that the sooner young scientists and engineers are introduced to the international scene the better, to profit from the intellectual stimulus and widening of horizons gained from an exposure to other people's problems and ideas. I will be interested to hear what the study group might have to say about this aspect of AGARD.

Turning to the future, I hesitate to don the mantle of prophet before such a distinguished gathering but I would like to touch on certain trends which I think have significance in the years ahead.

The first of these, of course, is the shift in the balance of military power between East and West. For some years now the strength and capability of the Warsaw Pact Forces has grown at a rate greater than our own. We have observed heavy Soviet investment in research and development and the fruits of that investment are

MINISTERIALRAT DR-ING. R.BARTH, National Coordinator for AGARD from the MOD in Bonn seen here with ex-officio National Delegates Board member Dr V.Garber, the NATO Assistant Secretary General for Defence Support

readily apparent in their front line equipment. This places a great responsibility on the scientific and engineering community within NATO to provide affordable solutions to redress the balance.

The second trend is the growth of new aircraft and associated industries in countries which formerly relied upon overseas supply. It would be easy for me, representing an established aircraft manufacturing country, not to welcome this development, partly because of the reduction in our markets but also because it runs counter to the need for greater concentration of resources as demonstrated by the trend in national aerospace industries. On the other hand, in the long run it could be beneficial to the industry as a whole, by opening up fresh opportunities for collaboration and partnership in various forms. Thus I think the world's major aeronautical companies should not be too concerned at this trend; it is a new challenge without doubt but if it serves to stimulate them to even greater competitiveness, it could be of considerable benefit to NATO as a whole.

The third trend is the growing ability of scientists and engineers to offer systems with radically improved performance but always it seems at greater increased cost and complexity. Unfortunately the new systems are sometimes more difficult to operate, and we need to remember that the armed forces are not manned exclusively by Bachelors of Science. We also must never forget that equipment must be rugged and capable of efficient operation in war by men who are both very tired physically and under heavy mental stress. So perhaps we should be concentrating more seriously on the well-known 'abilities' – reliability, maintainability, operability, etcetera, as well as on affordability, and less on performance improvements. Defence budgets are a major economic factor in every country and are themselves sensitive to economic pressures. I believe the rapidly rising costs of today's complex equipment must lead to increased cross-purchasing to secure the twin benefits of reduced national R & D costs and improved interoperability.

There is of course considerable inter-action between these trends but taken together and with many others they underline very forcibly the need for AGARD to continue to make an effective contribution to NATO. In this context I am very pleased that the draft terms of reference for your proposed study are so framed as to permit a wide-ranging study of AGARD's future role.

It has given my wife and myself very genuine pleasure to be with you this evening, to welcome you and renew past AGARD associations. I wish you all every success for the future in your NATO activities.

★ ★ ★

SUMMARY OF 1982 MEETING THEMES

AEROSPACE MEDICAL PANEL

Specialists' Meeting: **Impact Injury Caused by Linear Acceleration: Mechanisms, Prevention and Cost**
26 -29 April 1982, Cologne, Germany

Ten years ago the Panel organized a conference which brought together experts in linear acceleration effects, including parachuting, aircraft ejection seats, automobile crashes, fixed wing aircraft and helicopter crashes, impact injury mechanisms, impact test facilities and protective systems.

In the intervening decade the need for improved crash impact protection in NATO aircraft has increased largely because a big percentage are helicopters in which the only method of emergency escape is a landing under less than ideal conditions. Impact protection is important also in fixed wing aircraft in those accidents in which the living space of the occupants is maintained. Military land vehicles need impact protection against crashes and acceleration caused by blast loads from land mines and other ordnance.

The meeting will address these topics as well as the advances in injury mechanisms research and protective systems design.

39th Panel Meeting: (Classified)
4–7 October 1982, Copenhagen, Denmark

Invited Speakers will present to Panel Members, "The Female Aviator Programme", and other topics.

AVIONICS PANEL

43rd Panel Meeting/Symposium: **Advanced Avionics and the Military Aircraft Man/Machine Interface**
26–30 April 1982, Blackpool, UK

The Spring Symposium will be primarily for Specialists and will address the impact of avionics on the man/machine interface. Avionics systems and components state-of-the-art and the technology likely to be available within the next few years for application to combat aircraft design present an attractive picture at first sight. They offer an increase in combat capability and efficiency with reduced aircrew workload. The aim of this Avionics Symposium is to explore in depth several topics of importance in interfacing the aircrew of modern military aircraft with advanced avionics equipment and systems now becoming available. These items require in-depth coverage and are closely identified with the interface between the aircrew and the system. The Meeting will be planned primarily for specialists concerned with selected areas of research. Topics covered will include provision and use of colour displays, provision and use of voice control technology, and application of bio-mechanical/electrical models and other aids to combat aircraft cockpit design.

44th Panel Meeting/Symposium: **Software in Avionics**
6 -10 September 1982, The Hague, Netherlands

This Symposium will discuss the complex problems of software management and development. The last decade has brought about an explosion-like progress in electronic data processing technology. This can be mainly attributed to the continuously improving performance of semi-conductor devices with an ever increasing integration density, and the tremendously fast development of digital computers. While hardware costs for computers of all sizes are decreasing, costs and complexity of software are rapidly increasing. This problem has become even more critical since the implementation and application of advanced microprocessors and microcomputers. With the high degree of digitalization in avionics systems, software also determines to a large extent the mission critical performance in navigation, weapon delivery, flight control and defensive aids.

ELECTROMAGNETIC WAVE PROPAGATION PANEL

30th Panel Meeting/Symposium: **Propagation Effects on ECM-Resistant Systems in Communication and Navigation** (Classified)
24 28 May 1982, Copenhagen, Denmark

Steady advancement in adapting signal characteristics and modulation methods to modern transmission systems requires more and more attention to limitations governed by parameters other than technological ones. They mainly refer to effects caused by propagation media. Thus operational reliability may ultimately be controlled by the characteristics of this media, or in other words, by the anthropogeneous capability of adapting systems to variations in medium behavior. A particularly important field of system-oriented applications concerns communication and navigation systems resistant to Electronic Counter Measures. Propagation limitations may be identified in terms of several categories defined by scenarios, such as tactical operation in surface, vicinity, general long-distance links, and medium area coverage. This meeting is to deal with the present state-of-the-art and also discuss future possibilities.

31st Panel Meeting/Symposium: **Propagation Aspects of Frequency Sharing and Interference, and Systems Diversity**
18 -22 October 1982, Paris, France

Increased demand for radio services has necessitated the sharing of radio frequencies between terrestrial services, space services, and between services in both categories. Further demand will call for more sharing assuming this is technically feasible, and the possibility will depend critically on propagation factors. In assessing such possibilities the following questions regarding propagation are posed: How do propagation factors affect the practicability of frequency-sharing between services? The amount of spectrum needed for each service? The limits on radiated power which may be necessary to avoid interference between services?

The incidence of interference depends on the statistical distribution of the ratio of interfering and wanted signals. Assuming the reliability of the wanted signal, a determination of the interfering signals which may be present for small, but unacceptable, percentages of time has to be made.

This Meeting will address all aspects of the above problem.

FLIGHT MECHANICS PANEL

60th Panel Meeting/Symposium: **Criteria for Handling Qualities of Military Aircraft**
19–23 April 1982, Ft Worth, USA

The most suitable format of criteria for handling qualities of piloted aircraft can depend on the type of control system used in the aircraft. New control system techniques may lead to modification of existing criteria or even the establishment of new criteria. Moreover, criteria for degraded conditions of the control system have to be established.

The last full FMP meeting on this topic was in 1971; since that time there has been additional research, and, in the US, up-dating of the existing MIL-F8785-B requirements is being undertaken. It is felt timely to readdress the subject, including treatment of rotorcraft, VTOL and STOL handling qualities. The Symposium will consider the following main areas:

- Present status of criteria.
- Gains achieved in the '70s, and future prospects (CTOL, STOL and VTOL).
- Criteria for handling qualities at high angles of attack (including stall, post-stall and spin).
- Special problems (e.g. impact of advanced flight control systems).
- Techniques for the determination of handling qualities.

61st Panel Meeting/Symposium: **Ground/Flight Test Techniques and Correlation**
11–15 October 1982, Çeşme, Turkey

The emphasis of this meeting will be on aspects of correlation rather than on techniques. A previous meeting on the subject, in 1975, indicated many uncertainties in the extrapolation from ground tests to real flight conditions, and a further review of progress is justified. The meeting will include examination of ground and in-flight

means to predict the performance and flying qualities of a new aircraft, including analytical prediction, wind tunnels, ground and in-flight simulators, and flight demonstrators, and will also include some explanation of the test techniques used to gather the data. Sessions will address correlation in the areas of performance, flying qualities, buffet and flutter, and in subsystem testing. A Round Table Discussion will address the relative advantages or disadvantages of the various test methods.

FLUID DYNAMICS PANEL

50th Panel Meeting/Specialists' Meetings: **Prediction of Aerodynamic Loads on Rotorcraft, and Wall Interference in Wind Tunnels**
17–21 May 1982, London, UK

The primary theme of the first meeting is the prediction and experimental verification of the steady and unsteady aerodynamic forces on the rotors of modern helicopters and related devices. Participants will present, discuss, and critique recent developments in this field in order to assess the assumptions, capabilities and limitations of the current methodology and to identify specific areas that need further effort. Sessions on rotor blade aerodynamic characteristics, wakes and aerodynamic interference effects of rotorcraft and wind turbines, rotor airloads prediction programs, and experimental correlations and verification are planned.

The meeting on wind tunnels will review and assess the current status of wall interference correction methods and adaptive wall research. Extensive research has been conducted to account for the effects of the wind tunnel upon aerodynamic testing conducted therein, either through analytical correction of data or through removal of effects by mechanisms such as ventilated or compliant walls. Sessions on solid, ventilated and adaptive wall tunnels and correction methods are planned.

51st Panel Meeting/Symposium: **Aerodynamics of Missiles. Round Table Discussion on Two-Phase Flow**
20–25 September 1982, Trondheim, Norway

The symposium will survey current and foreseeable aerodynamic problems in tactical guided weapon design and review recent work which has improved basic understanding or enhanced prediction and design methods. Theoretical, numerical, experimental and empirical methods for guided missiles, projectiles and bombs will be covered over the subsonic through hypersonic flight régimes. Control and propulsion aspects are included in a broad cross-section of aerodynamic problems peculiar to weapon system design.

The round table discussion on two-phase flow will survey important work in this field in the NATO countries and serve as a planning session for future panel activities in this field.

GUIDANCE AND CONTROL PANEL

34th Panel Meeting/Symposium: **Precision Guided Munitions; Technology and Operational Aspects** (Classified)
3–7 May 1982, Spatind, Norway

In the face of the Warsaw Pact Forces, of overwhelming numerical superiority, it is absolutely essential to utilize, effectively, high-kill-probability weapons systems, referred to as PGMs. The target environment includes such elements as tanks, armoured personnel carriers, self-propelled Howitzers, air defense systems, concrete airfield runways. The tactical importance of destruction of this array of Warsaw Pact Forces elements with high-kill-probability weapons is important in and of itself. There are other facets to this tactical requirement. One of these is that the advance of Warsaw Pact Forces can be expected to occur at a highly rapid rate unless deterred by high-kill-probability PGMs. While a PGM would ordinarily be expected to be more costly than unconventional munitions, a PGM will generally be far more cost-effective. It is clear that such a meeting on the guidance and control systems issues of such PGMs is of great timely importance to NATO.

The meeting will consist of five sessions: Systems Analysis, Supporting Technology, Seeker Technology, Guidance and Control, Weapon Developments.

35th Panel Meeting/Symposium: **Advances in Guidance and Control Systems** (Classified)
11–15 October 1982, Lisbon, Portugal

The last Guidance and Control Panel symposium held on this subject was in 1973 in Geilo, Norway. Many significant advances in optimal control theory, synthesis techniques and design methodology have taken place since that time. It is therefore considered timely to hold a symposium in 1982 on advances in guidance and control systems. This symposium will treat all aspects of the technology from control theory through system applications including aircraft, missiles, space vehicles and unmanned vehicles.

This symposium will comprise the following sessions: Advances in control theory; Advanced design and performance optimization, component design and reliability; Advanced system design architecture and interfaces; Advances in synthesis, simulation and validation techniques; Recent systems applications including flight test and simulation.

PROPULSION AND ENERGETICS PANEL

59th Panel Meeting/Symposium: **Problems in Bearings and Lubrication**
31 May–4 June 1982, Ottawa, Canada

The purpose of the meeting is to provide research scientists, development engineers and applications specialists with a broad overview of advanced bearings and lubrication technology with emphasis on high-speed bearings suitable for aircraft, missiles and aerospace applications.

The scope of the meeting includes all technical aspects of rolling bearings for high rotational speed, hydrostatic bearings and journal bearings, and also the lubrication of bearings and gears. The mechanical design of these various bearing types, their capabilities, their manufacturing and materials problems, their application and operational aspects, their users' experiences and their future potential are included in the scope of the meeting. Lubrication aspects include the chemistry and properties of liquid lubricants, additives, self-lubricating materials, lubricant-air mixtures and application experience.

60th Panel Meeting/Symposium: **Engine Handling**
11–15 October 1982, Agios Andreas, Greece

The Symposium will focus on engine handling characteristics and transient behavior, emphasizing: operational experience, design criteria, and necessary research. A general definition of engine handling has been offered as: "achieving a desired state with a minimum of manual effort in the shortest possible time without any undue safety risks".

The "desired state", with high-performance combat aircraft, often is a power level and load factor different than current, with a life-or-death premium on reaching it quickly. Additionally, recently-developed combat aircraft have significantly more powerful engines which are complicated and highly sophisticated so as to remain within strict weight and volume constraints. Consequently, transients in engine power levels, "g" loadings, and intake angles of attack have become significantly more severe, requiring employment of more sophisticated techniques to understand their effects on engine design, and to minimize performance and life penalties.

The Symposium will address four topics: 1. field operational requirements and experience with combat aircraft engine handling; 2. aerothermodynamic interactions and modelling in engine handling; 3. thermal transient effects on engine component characteristics; and 4. control system concepts for advanced engine handling.

STRUCTURES AND MATERIALS PANEL

54th Panel Meeting/Specialists' Meetings: **Aircraft Dynamic Response to Damaged and Repaired Runways** (Classified). **Advanced Casting Technology**
4–9 April 1982, Brussels, Belgium

The first Meeting will bring together experts in military operations, runway repair, landing gear design, aircraft structural dynamic response and dynamic testing to explore areas of concern: the requirements of the military commander in the field, the aircraft designer and the certifying authorities; the variability of existing runways,

damage criteria, repair procedures and expected post-repair profiles; the development of mathematical modeling techniques for aircraft tires, landing gears, primary structure and store attachments; simplification of mathematical solutions and reduction in the time, hazard and cost of testing and validation of mathematical models; the development of simple rules to assess the safety of runway operations; recommendations for the ingredients of Military Specifications and Standards.

The second Meeting responds to the requirement within the NATO nations to reduce acquisition costs of aircraft and equipment as part of the drive to reduce lift cycle costs. Castings used to replace complicated fabricated/machined components could potentially lead to cheaper manufacture, but traditionally many designers have been reluctant to trust castings. The Meeting is intended to present the current state of development of Advanced Casting Technology, and bring together designers and materials and processing engineers for a full exchange of views so that areas of lack of knowledge that are limiting the use of castings can be highlighted.

55th Panel Meeting/Specialists' Meetings: **Environmental Effects on Materials for Space Applications. Behaviour of Short Cracks in Airframe Components**
19–24 September 1982, Toronto, Canada

Systems requirements for future spacecraft and antennas with long duration of flight exert significant constraints on the design of the structure. The first Meeting will review these requirements in terms of lifetimes, dimensional stability, tolerable degradation of surface properties and interaction with other components. The physical implications of space environment and existing data on the variation of material properties with the environment will be considered. Finally, techniques for real-time and accelerated testing, including effects of vacuum conditions and dynamic qualification criteria, will be addressed.

New specifications for durability and fatigue strength of aircraft structures require that small cracks, which will be initiated during production or in an early life period, will not propagate to a critical crack length within a specified lifetime. An exchange of experience gained by different designers of various countries will promote a better understanding of the problem. The mechanisms of the growth of small cracks and the impact of small crack growth behaviour on aircraft structural design will be considered, as well as analysis methods, loading effects and correlation between test and analysis.

TECHNICAL INFORMATION PANEL

35th Panel Meeting/Specialists' Meeting: **Use of Scientific and Technical Information in the NATO Countries**
27 September–1 October 1982, Rome, Italy

As is usual, the Technical Information Panel will hold one meeting during the year. Its title and theme for the Specialists' Meeting have been selected in consultation with the local National Authorities, and with the defence community in particular. The main objective is to disseminate more widely information concerning the demand for, and utilization of, scientific and technical information services in the NATO Countries, and particularly those services operating in the fields of aerospace and defence. The increase in such demand is well-known. What are less well-recognized are the specific nature of these requirements and how Government Departments and Agencies, Universities, and Industrial Organizations are coping with them.

The Meeting will address the structure and operation of defence information centers in the NATO countries; requirements for networking, translation services, and communications access and present current capabilities in the areas of on-line services, data bases, and document delivery systems. Problems encountered in Italy in meeting current requirements will be specifically addressed.

LECTURE SERIES

Following the proposals made by AGARD panels, the Consultant and Exchange Programme proposes to implement seven Lecture Series during the year 1982.

The numerous requests received from the NATO nations made it necessary to slightly increase the level of effort concerning the number of presentations, which will be held at twenty locations in 1982, instead of sixteen locations as in 1981.

The proposed budget includes the printing of the Lecture Series publications as well as the cost of preparation of the Lecture Series: travel expenses, subsistence allowance and honoraria, when appropriate, for participating speakers.

Lecture Series No.119: **Image Processing Techniques** (with the Avionics Panel)
14–15 June 1982, Athens, Greece
17–18 June 1982, Paris, France
21–22 June 1982, The Hague, The Netherlands

The Lecture Series will commence with a summary on human visual system capabilities and limitations. Fundamentals of imagery and display will be covered including analog and digital parameters, contouring, scan conversion, image generation, and interpretation. A session will be devoted to optical image processing, including image enhancement, edge detection, and filtering.

Digital image processing, transmission and coding, including colour will be covered.

Image enhancement will be emphasized. One session will be devoted to hardware implementations and applications. Trade-offs between digital versus analog and real-time versus off-line will be discussed.

Lecture Series Director: Prof. L.Gerhardt, Rensselear Polytechnic Institute, USA.

Lecture Series No.120: **EM Propagation Problems in the Tactical Environment** (with the Electromagnetic Wave Propagation Panel)
3–4 May 1982, Munich, Germany
6–7 May 1982, Paris, France

Due to the rapidly increasing employment of electronic equipment in battlefield activities, many of which are dependent on characteristics of the propagation medium, personnel must possess adequate knowledge of system relevant propagation criteria. They must also be trained to a level which permits efficient reaction under changeable battlefield conditions.

Lectures will include a general review of EM spectrum characteristics in tactical applications. There will be tutorial lectures on criteria of ground-wave propagation, aspects of ionospheric links over short and medium distances, limitations in scatter propagation, characteristics of satellite links, and aspects of antenna near-field conditions.

There will also be systems oriented lectures on propagation problems in: combat-net radio, radio-relay links, air/ground/air and air/air communications multifunction information distribution systems, tactical radar, and C^3.

Lecture Series Director: Dr H.J.Albrecht, Forschungsgesellschaft für Angewandte Naturwissenshaften Wachtberg-Werthhoven, Federal Republic of Germany.

Lecture Series No.121: **High Angle of Attack Aerodynamics** (with the Fluid Dynamics Panel)
10–11 March 1982, Langley, USA
15–19 March 1982, VKI, Brussels, Belgium
22–23 March 1982, Göttingen, Germany

Manoeuverability requirements for missiles currently include angles of attack up to 90°. Future combat aircraft for the 1990's will need to manoeuver at supersonic speeds and angles of attack above 60°. This Lecture Series will cover applications to both aircraft and missiles since the problems are similar. The fundamental aspects of large-scale separated flows, three-dimensional and unsteady aerodynamics, favourable interference from strakes and canards and analyses of vortices will be covered across a wide speed range.

The Lecture Series will draw on the experience of the Panel in the conduct of a Symposium on the subject.

Lecture Series Director: Dr J.Wendt, von Kármán Institute, Rhode St.Genese, Belgium.

Lecture Series No.122: **Application of Digital Mapping Technology to Guidance and Control Systems** (Classified) (with the Guidance and Control Panel)
6– 7 September 1982, Rome, Italy
9–10 September 1982, Agios Andreas, Greece
13–14 September, London, UK

The Lecture Series is intended to address the theoretical analysis, functional and implementation techniques involved in the application of Digital Mapping Technology to guidance and control systems. Areas that will be addressed are computer-generated information requirements, methods of integrating positioning systems and the computation requirements associated with guidance and control integration. Emphasis will be placed upon the

analysis, functional and simulation techniques to provide the necessary informational and functional capabilities. New procedures in analysis and estimation techniques will be stressed. This will provide one document which covers the necessary design background and state-of-the-art involved in the application of advancing technologies.

Lecture Series Director: Mr R.R.Newbery, Royal Aircraft Establishment, Bedford, UK.

Lecture Series No.123: **Aircraft Fire Safety** (with the Propulsion and Energetics Panel)
7– 8 June 1982, Oslo, Norway
10–11 June 1982, London, UK
15–16 June 1982, Washington, DC, USA

The Lecture Series will be based on the results of the AGARD PEP Working Group 11, on the same subject. The results were published in the AGARD Advisory Report No.132, Volumes I and II.

In the presentations the results will be updated and will be concentrated on the enhancement of passenger and crew fire survivability under aircraft crash conditions. Survivability represents the highest priority in fire safety needs.

The contents will cover:

- Aircraft mishap experience with respect to definition of post-crash fire scenario/survivability factors.
- Availability and operational suitability of aviation fuels versus fire safety enhancement.
- Applicability of aircraft sub-system fire protection engineering techniques for enhancement of post-crash fire survivability.
- Interior cabin materials and their influences on post-crash fire survivability.
- Aircraft post-crash survivability – human response factors – physiological, and psychological.

Lecture Series Director: Mr B.P.Botteri, Aero-Propulsion Laboratory, Wright Patterson Air Force Base, Ohio, USA.

Lecture Series No.124: **Practical Considerations of Design, Fabrication and Tests for Composite Components** (with the Structures and Materials Panel)
11–12 October 1982, Oporto, Portugal
14–15 October 1982, London, UK
18–19 October 1982, Ankara, Turkey

The Lecture Series will be directed at the practical application of composites to structures. The scope will include a lecture on design considerations involving material selection, fabrication techniques, and tooling concepts. Stress analysis will be covered including knockdown factors, load transfer concepts and analytical techniques. The Lecture Series will be concluded with a lecture on qualification requirements and practical consideration in inspection and testing techniques. These lectures will not be geared to the day-to-day developments on the very forefront of technology, but rather to state-of-the-art concepts, techniques, and materials that when combined will assure a high probability of success in achieving design goals for cost as well as weight savings.

Lecture Series Director: Prof. B.Harris, University of Bath, UK.

Lecture Series No.125: **Human Factors Aspects of Aircraft Accidents** (with the Aerospace Medical Panel)
4– 5 November 1982, Lisbon, Portugal
8– 9 November 1982, Ankara, Turkey
11–12 November 1982, Athens, Greece

Aircraft accident investigation technology varies considerably from nation to nation in the NATO community. Specific investigative techniques and development of data bases show similar variations. All our nations wish to profit from lessons learned but its effectiveness is dependant upon the adequacy of technology, procedures and data bases. With the introduction of high performance/multi-role aircraft, the human factors aspects of aircraft accidents have assumed increasing importance. The objective of this Lecture Series is to provide a broad review of the issues identified above.

The Lecture Series will comprise a broad-based review of the important sub-specialities of accident investigation as a base on which can be overlaid the human factors aspects.

Topics presented will include:

- Introduction/current status/statistical description of the past ten years.
- Medico/clinical aspects.
- Physiology/psychophysiology aspects.

– Engineering/crash worthiness aspects.

– Life support/escape aspects.

– Medico-legal/pathology aspects.

It is anticipated that the audience will be operational staff, both general officers and field grade officers plus senior physicians in staff/management positions, and line officers of the various safety branches.

Lecture Series Director: Dr B.Hartman, Texas, USA.

MILITARY COMMITTEE STUDIES

22nd Meeting of the **Aerospace Applications Studies Committee** (Classified)
10–12 May 1982, Naples, Italy

The Committee will hold the initial review of AAS-16 "Stand-off System Concepts for the Acquisition and Neutralization of Mobile Surface Targets" and the final review of AAS-15 "Active, Semi-Active and Passive Surveillance Sensors and Fire Control for Air Defence". Terms of reference for AAS-17 and 18 will be finalized and the organization of AAS-17 will be established.

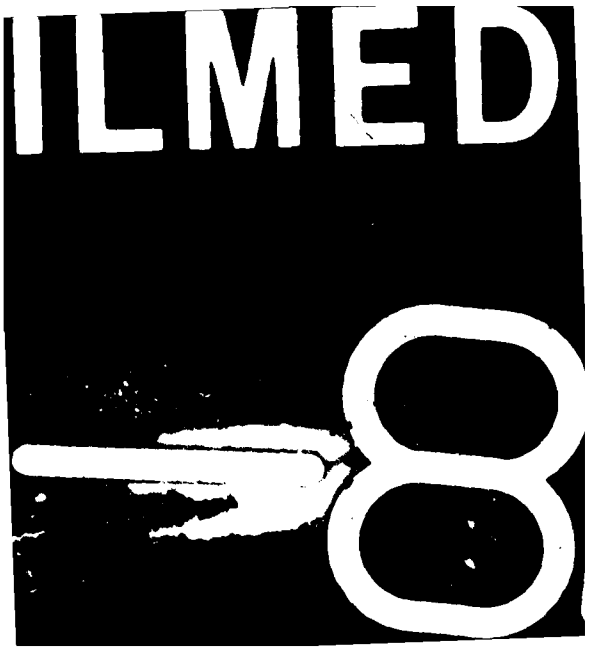
23rd Meeting of the **Aerospace Applications Studies Committee** (Classified)
15–17 November 1982, Munich, Federal Republic of Germany

The final review of AAS-16 "Stand-off System Concepts for the Acquisition and Neutralization of Mobile Surface Targets" and the initial review of AAS-17 will be accomplished. Proposals for new Aerospace Applications Studies will be reviewed and their Terms of Reference refined as required. The organization for the AAS-18 Study Group will be established. Terms of Reference for AAS-18 will be finalized.

Any other business....

CHURCH HOUSE, WESTMINSTER, London, well-known as a meeting place for AGARD Panels, forms the backdrop to this picture of the Propulsion and Energetics Panel during their Ramjet and Ramrockets symposium in October last year

WOLFGANG MACH (extreme right), Head of the Information Department at the MBB plant in Ottobrun, FRG, hosts a visit by the AGARD Technical Information Panel in the course of their Specialists' Meeting held in Münich last September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